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ABSTRACT

"New Standards" is the result of a collaboration between the Learning Research and Development Center and the National Center on Education and the Economy, in partnership with states and urban districts, working to build an assessment system with which to measure students' progress toward meeting national standards at internationally benchmarked levels. The New Standards assessment system has three interrelated components: (1) performance standards; (2) an on-demand examination; and (3) a portfolio system. Standards are provided for English Language Arts, Mathematics, Science, and Applied Learning at the high school level. (Contains 27 references.) (ASK)

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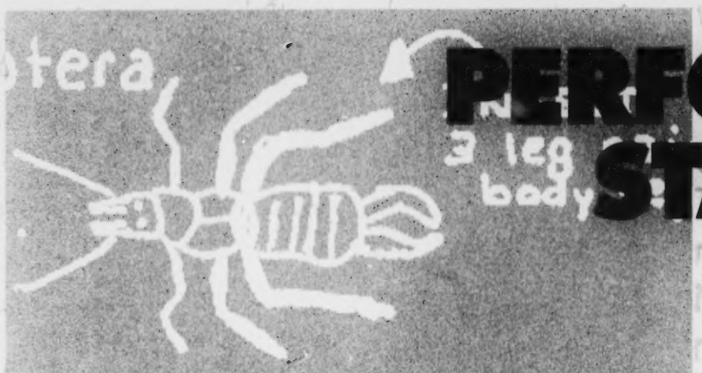
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PERFORMANCE STANDARDS

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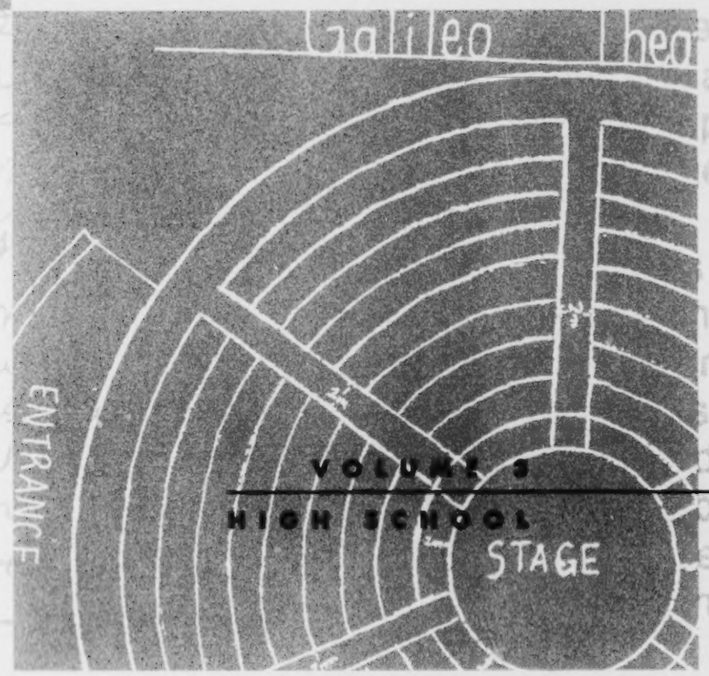
Mathematics

Science

Applied Learning



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NEW
STANDARDS

Consultation Draft

PERFORMANCE STANDARDS

English Language Arts

Mathematics

Science

Applied Learning

VOLUME 3

HIGH SCHOOL

NEW
STANDARDS

Consultation Draft

Support for the development of these Performance Standards was provided by:

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and the
New Standards' Partners

RESPONDING TO THIS DRAFT

We welcome your response to this Consultation Draft.
A Comments and Feedback Form is enclosed.
Responses need to reach us no later than 3 May 1996 to be considered
in the preparation of the next version of these Performance Standards.
Additional Comments and Feedback Forms can be obtained by contacting
New Standards, LRDC, University of Pittsburgh, 3939 O'Hara Street,
Pittsburgh, PA 15260; Tel. 412-624-8319; Fax. 412-624-1470;
dedwards@vms.cis.pitt.edu.

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Introduction

ABOUT NEW STANDARDS

New Standards is a collaboration of the Learning Research and Development Center of the University of Pittsburgh and the National Center on Education and the Economy, in partnership with states and urban districts, working to build an assessment system to measure their students' progress toward meeting national standards at levels that are internationally benchmarked.

The Governing Board includes chief state school officers, governors and their representatives, and others representing the diversity of the partnership, whose jurisdictions enroll nearly half of the Nation's students.

Founded by Lauren Resnick, Director of the Learning Research and Development Center (LRDC), and Marc Tucker, President of the National Center on Education and the Economy, New Standards' staff is based at these organizations as well as the American Association for the Advancement of Science, the Fort Worth Independent School District, the National Council of Teachers of English, and the University of California Office of the President. Technical studies are based at LRDC and Northwestern University, advised by leading psychometricians from across the nation.

The New Standards' assessment system has three interrelated components: performance standards, an on-demand examination, and a portfolio system.

The **performance standards** are derived from the national content standards developed by professional organizations, e.g., the National Council of Teachers of Mathematics standards in Mathematics, and consist of two parts:

- **Performance descriptions**—descriptions of what students should know and the ways they should demonstrate the knowledge and skills they have acquired in the four areas assessed by New Standards—English Language Arts, Mathematics, Science, and Applied Learning—at elementary, middle, and high school levels.
- **Work samples and commentaries**—samples of student work selected for their capacity to illustrate the meaning of the performance descriptions together with commentary that shows how the performance descriptions are reflected in the work sample.

The performance standards were endorsed unanimously by the New Standards' Governing Board in June 1995 for widespread consultation in 1995–96.

The on-demand examination, called the **reference examination** because it provides a point of reference to national standards, is currently available in English Language Arts and Mathematics at grades 4, 8, and 10. It assesses those aspects of the performance standards that can be assessed in a limited time frame under standardized conditions. In English Language Arts, this means reading short passages and answering questions, writing first drafts, and editing. In Mathematics, this means short exercises or problems that take five to fifteen minutes and longer problems of up to forty-five minutes' duration. The reference examination stops short of being able to accommodate longer pieces of work—reading several books, writing with revision, conducting investigations in Mathematics and Science, and completing projects in Applied Learning—that are required by New Standards' performance standards and the national consensus content standards from which they are derived.

The **portfolio system** complements the reference examination, providing evidence of the performance standards that depend on extended pieces of work (especially those that show revision) and accumulation of evidence over time. In 1994–95, using draft portfolio handbooks in English Language Arts and Mathematics, 3,000 teachers and almost 60,000 students participated in a field trial of the portfolio system. In addition to handbooks for students, teachers, and administrators, the current system provides example portfolios that contain concrete examples of expectations for students and teachers.

This year the portfolio system trial is being extended to include Science and Applied Learning. The system has been revised to take account of the experience of the first year, with the goal of making it easier to understand and implement.

ABOUT THE PERFORMANCE STANDARDS

We have adopted the distinction between content standards and performance standards that is articulated in *Promises to Keep: Creating High Standards for American Students* (1993), a report commissioned by the National Education Goals Panel. Content standards specify "what students should know and be able to do;" performance standards go the next step to specify "how good is good enough."

These standards are designed to answer the question: how good is good enough?

Where do the standards come from?

The standards are built directly upon the consensus content standards developed by the relevant professional organizations. The Mathematics standards are based directly on the content standards produced by the National Council of Teachers of Mathematics (1989). Similarly the standards for English Language Arts are being developed in concert with the content standards currently being produced by the National Council of Teachers of English and the International Reading Association.

The Science standards are founded both upon the American Association for the Advancement of Science's Project 2061 *Benchmarks for Scientific Literacy* (1993) and the National Research Council's *National Science Education Standards draft.* (1995). The Science standards will also take into account the work of the National Science Teachers Association as they revise their *Scope, Sequence, and Coordination Content Core* (1992) and develop assessment tasks.

The case of the Applied Learning standards is a little different. Applied Learning focuses on the requirements for effective participation in the emerging forms of work and work organization characterized by high performance work places. As a newer field of school education, Applied Learning does not yet have a distinct professional constituency producing content standards on which the performance standards can be built. However, a start has been made by the work of the Secretary's Commission on Achieving Necessary Skills which defined "Workplace Know-how" in its report, *Learning a Living: A Blueprint for High Performance* (1992). We have worked from this foundation and from comparable work internationally to produce our own *Framework for Applied Learning* (New Standards, 1994). The Applied Learning standards are being built upon this draft framework.

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Standards for Standards

In recent years several reports on standards development have established "standards for standards;" that is, a set of guidelines for developing standards and criteria for judging their quality. These include the review criteria included in *Promises to Keep*, the American Federation of Teachers' "Criteria for High Quality Standards," published most recently in *Making Standards Matter* (1995), and the "Principles for Education Standards" developed by the Business Task Force on Student Standards and published in *The Challenge of Change* (1995). The headings below are borrowed or adapted from the criteria and principles advocated in those documents.

Standards should establish high standards for all students.

The New Standards' partnership has resolved to abolish the practice of expecting less from poor and minority children and children whose native language is not English. These standards are intended to help bring all students to high levels of performance.

Much of the onus for making this goal a reality rests on the ways the standards are implemented, but part of it lies in the design of the standards themselves. We are working to make the expectations included in the standards as clear as possible. For some standards it has been possible to do this in the performance descriptions. For example, the reading standard includes expectations for students to read widely and deeply. Instead of simply exhorting them to do this, we have given more specific direction by specifying that reading includes at least twenty-five books each year, books of the quality and complexity illustrated in the sample reading list for each grade level. In Mathematics, we have gone beyond simply listing problem solving among our expectations for students. In addition, we set out just what we mean by problem solving and what things we expect students to be able to do in problem solving and mathematical reasoning.

What distinguishes these standards from most others is the use of samples of student work to illustrate what they mean, especially for standards that are hard to pin down clearly in words alone. In the writing standard, for example, the work samples show the expected qualities of writing in the various genres as well as criteria for assessment matched to the genres.

The work samples are intended to be used by teachers, students, and parents, to help them picture work that meets standards and to establish goals to reach for. Students need to know what work that meets standards looks like if they are to strive to produce work of the same quality. They also need to see themselves reflected in the work samples if they are to believe that they too are capable of producing such work. We have taken care to include work samples drawn from a diverse range of students.

Standards should be rigorous and world class.

Is what we are asking of our students as rigorous and demanding as what is expected of young people in other countries—especially those countries whose young people consistently perform as well as or better than ours?

That is the question we are trying to answer when we talk about developing world class standards.

Throughout development of the standards, we have compared them with national and local curricula of other countries, textbooks, assessments, examinations and, where possible, with student work. Ultimately it is in the work that students produce that we will discover whether claims for world class standards can be supported.

We have shared the standards with researchers in several countries and asked them to review them in terms of their own country's standards and in light of what is considered world class in their field. We have asked these reviewers to tell us whether each standard is at least as demanding as its counterparts abroad and whether the set of standards represents an appropriately thorough coverage of material.

The information collected so far indicates that the standards we are defining are world class. To show this we have included "world class connections" throughout this volume. World class connections are examples of the work students in selected countries are expected to do. They are included to allow comparison with these performance standards.

Standards should be useful, developing what is needed for citizenship, employment and life-long learning.

The core disciplines provide the strongest foundation for learning what is needed for citizenship, employment, and life-long learning. We have established explicit standards in each of the core areas of English Language Arts, Mathematics, and Science. But there is more. In particular, it is critical for young people to achieve high standards in Applied Learning—the fourth area we are working on.

Applied Learning is about the capabilities people need to be productive members of society, as individuals who apply the knowledge gained in school and elsewhere to analyze problems and propose solutions, to communicate effectively and coordinate action with others, and to use the tools of the information age workplace.

Applied Learning is not about "job skills" for students who are judged incapable of, or indifferent to, the challenges and opportunities of academic learning. They are the kinds of abilities all young people will need, both in the workplace and in their role as citizens. They are the thinking and reasoning abilities demanded by both colleges and the growing number of high performance workplaces, those that expect employees at every level of the organization to take responsibility for the quality of products and services. Some of these abilities are familiar; they have long been recognized goals of schooling, though they have not necessarily been translated clearly into expectations for student performance. Others break new ground; they are the kinds of abilities we now understand will be needed by everyone in the near future. All are skills attuned to the real world of responsible citizenship and dignified work that values and cultivates mind and spirit.

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Standards for Standards

Standards should be important and focused, parsimonious while including those elements that represent the most important knowledge and skills within the discipline.

As anyone who has been involved in a standards development effort knows, it is easier to add to standards than it is to limit what they cover. It is especially easier to resolve disagreements about the most important things to cover by including everything than it is to resolve the disagreements themselves. We are trying not to take the easier route. We have adopted the principle of parsimony and are trying to practice it. At the same time we are concerned not only to include those elements that represent the most important knowledge and skills within a subject area, but also to make those elements explicit. The approach we have adopted distinguishes between standards as a means of organizing the knowledge and skills of a subject area and as a reference point for assessment, and the program through which the work designed to enable students to achieve the standards is delivered.

For example, the conceptual understanding standards in Mathematics and Science are explicit about the concepts that students should understand at each grade level and in English Language Arts we have established a separate standard for conventions, grammar, and usage. This does not imply that conventions, grammar, and usage should be taught in isolation from other elements of English Language Arts. What it does imply is that the work students do should be designed to help them achieve the standard for conventions. It also implies that conventions should not only be among the things assessed but should also be a focus of explicit reporting of student achievement.

Standards should be manageable given the constraints of time.

This criterion follows very closely on the last one, but focuses particularly on making sure that standards are "doable." One of the features of this standards development effort is the level of interaction among the staff working on the different subject areas. We view the standards for the four areas as a set at each grade level; our publication of the standards by grade level reflects this orientation. This orientation allows us to avoid unnecessary overlaps and duplication across subject areas and to recognize and use opportunities for forging stronger connections among subject areas through the work that students do. A key to ensuring the standards are manageable is making the most of opportunities for student work to do double and even triple duty. These standards include several work samples that demonstrate the way a single project or task can generate student work relevant to more than one standard within a subject area and to standards in more than one subject area.

Standards should be adaptable, permitting flexibility in implementation needed for local control, state and regional variation, and differing individual interests and cultural traditions.

These standards are intended for use in widely differing settings. One approach to tackling the need for flexibility to accommodate local control, state and regional variation, and differing individual interests and cultural traditions, is to make the standards general and leave their translation into more specific statements for users at various levels. We have not adopted that approach. These standards need to be specific enough to guide the New Standards' assessment system; we have tried to make them specific enough to do so. We have also tried to achieve the necessary degree of specificity without unduly limiting the kinds of flexibility outlined above. As we have already mentioned, we are concerned to ensure that the work samples included to show the quality of work expected for meeting the standards come from the work of a diverse range of students. However, the specificity needed for standards intended to guide an assessment system does place limits on flexibility. To tackle these apparently contradictory demands on the standards, we have adopted the notion of "substitution." This means that when users of these standards identify elements in the standards that are inconsistent with decisions made at the local level, they can substitute their own. An example of this is the Reading standard in English Language Arts. The Reading standard states that students should read and comprehend, and specifies that they should read material of the quality and complexity illustrated in the sample reading list equivalent to twenty-five books each year. We have included the reading list so as to be clear about the quality of reading material we are talking about at each grade level. But we would not claim that this is the only reading list that would be appropriate. Thus, users who have established their own lists and are satisfied with them can replace the lists provided with their own. There is one important proviso, however. Substitution only works where what is added to the standards is comparable with the material it replaces in terms of both quality and quantity of expectation.

Standards should be clear and usable.

Making standards sufficiently clear so that parents, teachers, and students can understand what they mean and what the standards require of them is essential to the purpose for establishing standards in the first place. It is also a challenge because while all of these groups need to understand what the standards are, the kinds of information they need are different. The most obvious difference is between the way in which the standards need to be presented to elementary school students so that they know what they should be striving to achieve and the way in which those same standards need to be presented to teachers so that they can help their students get there. If the standards were written only in a form that elementary school students could access, we would have to leave out information teachers need to do their job.

These standards are being presented in several formats. This version of the standards is written primarily for teachers. It includes technical language about the subject matter of the standards and terms that educators use to describe differences in the quality of work students produce. It could be described as a technical document. That does not mean that parents and students should not have access to it, but it does mean that it includes language that may be difficult for students to comprehend and more detail than some parents may want to deal with.

Another version of the standards is in preparation. It is being written with parents and the community in general in mind. The standards will be the same but they will be explained in less technical language.

Standards should be reflective of broad consensus building, resulting from an iterative process of comment, feedback, and revision including educators and the general public.

This consultation draft is the result of revisions of earlier drafts on the basis of comment and feedback from reviewers nominated by the New Standards' partners and the New Standards' advisory committees for each of the subject areas, as well as other educators. Earlier drafts have also been the subject of review by focus groups of parents and other members of the general public.

This draft is being made available widely as the basis for review and comment through to the spring of 1996. A final version will be prepared for endorsement by the New Standards' Governing Board in June 1996.

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How Will the Performance Standards be Used?

The primary audience for these performance standards is teachers. We hope that teachers will use the standards to:

- help students and parents understand what work that meets standards looks like;
- inform discussions with their colleagues as they plan programs to help students learn to high standards;
- challenge assumptions about what we can expect from students;
- communicate the meaning of high standards to district administrators, school board members, and the public so they can work together to build learning environments that challenge all students.

New Standards will use the performance standards to provide:

- the basis of design specifications for the New Standards' assessment system;
- the basis for reporting student scores on assessments within the New Standards' system; and
- the basis for linking the New Standards' assessment system with the standards and assessment systems of the members of the New Standards' partnership.

Design specifications for the New Standards' assessment system

The New Standards' assessment system has two components: portfolios of work demonstrating performances produced by students over extended periods of time and with opportunities for revision; and examinations (known as reference examinations) completed under on-demand conditions.

The portfolio system has already been developed and trialed in English Language Arts and Mathematics, and reference examinations in those subjects have been developed and administered on a pilot basis. The performance standards will provide the basis of design specifications for the portfolio and examination systems in English Language Arts and Mathematics as these are progressively revised and refined. They will similarly provide the basis of design specifications for development of the assessment systems for Science and Applied Learning.

Student scores on assessments reported by standards

Student scores on assessments within the New Standards' system will be reported by standards; that is, student achievement will be reported in the form of a "profile" of scores, with each score reporting achievement in relation to one of the performance standards. Reporting students' scores in this way will provide richer and more comprehensive information about student achievement than can be provided by a single score.

Linking the New Standards' system with partners' standards and assessment systems

"Linking" is the process of establishing the extent and degree of match between the New Standards' system and those of the New Standards' partners. It is an essential step in the process of enabling partners to make decisions about their use of the New Standards' system, either in part or as a whole.

Linking is crucial for assuring that student work is assessed according to the same standards that guided its production.

The performance standards will provide the initial point of reference for the linking process. While comprehensive linking of assessment systems will require the further step of linking scores on performances, linking standards is a necessary first step and will provide a good indication of the potential for linking New Standards with partners' systems.

The linking process is underway with a small number of partners. This work has produced a protocol to guide the process. Linking will take place concurrently with the consultation and review phase of development of the performance standards. This will make it possible for the results of the linking process to inform review of the performance standards prior to their presentation to the New Standards' Governing Board for adoption in June 1996.

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How to Read These Standards

The standards for high school are set out in an overview on page 10. The overview provides only the names of the standards for each of the four areas: English Language Arts, Mathematics, Science, and Applied Learning. To help you keep the complete set of standards in your mind as you work through this volume we have included a bar listing all the standards for high school along the top of most pages.

Performance descriptions tell what students are expected to know and be able to do.

Turn to the performance descriptions for English Language Arts on page 12. Each standard has a performance description. The performance description is a narrative description of what students are expected to know and be able to do.

High school level means the end of tenth grade.

The standards for high school are set at the level of achievement expected of students at about the end of tenth grade. Some students will achieve this level of performance earlier than the end of tenth grade. Some students will reach it later than the end of tenth grade.

Most standards are made up of several parts.

Most of the standards are made up of several parts, for example, the Reading standard has three parts.

The bold type shows what students should know and be able to do.

What is shown in bold type are the things students should know and be able to do.

Examples are the kinds of work students might do to demonstrate their achievement of the standards.

Immediately following the bold-typed description of the standard are examples of the kinds of work students might do to demonstrate their achievement. The examples also indicate the nature and complexity of activities that are appropriate to expect of students at the grade level. However, we chose the word "example" deliberately. The examples are intended only to show the kinds of work that students might do and to stimulate ideas for further kinds of work. None of the kinds of work shown in the examples is necessarily required to meet the standard.

Cross-references highlight examples of work that could meet the requirements of standards from two or more subject areas.

In a couple of instances, the examples that go with the English Language Arts performance descriptions include a cross-reference to one of the other subject areas. The cross-references highlight examples for which the same work, and possibly the same piece of work, may enable students to demonstrate their achievement of standards from more than one subject matter.

Most cross-references are to Applied Learning.

Most commonly the cross-reference is to Applied Learning. Applied Learning is not a subject area in its own right. It is expected that Applied Learning activities will generally take place within a subject such as English. The cross-references show work that may provide a vehicle for demonstrating standards within one or more subject areas as well as standards for Applied Learning.

Some cross-references also show the possibilities for using work from Mathematics or Science to demonstrate English Language Arts standards, and vice versa.

We have not tried to highlight every possible cross-reference, only to give an indication of the possibilities.

Margin notes draw attention to particular aspects of the standards.

The notes in the margin draw attention to particular aspects of the standards, such as the resources to which students need access in order to meet the requirements of the standards.

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Comparing the grade levels.

Each page showing performance descriptions has a note in the margin that directs attention to the Appendices which show the performance descriptions at each of the three grade levels: elementary, middle and high school.

Work samples and commentaries.

Next, turn to the work samples and commentaries that appear on the pages immediately following the performance descriptions.

Work samples illustrate "how good is good enough."

Each work sample is a genuine piece of student work. We have selected it because it illustrates the quality of work expected for one or more of the standards. In other words, it illustrates "how good is good enough."

(See "Not all standards are the same" below for more detail on how work samples illustrate standards.)

The commentary explains *why* the work illustrates how good is good enough.

The commentary that goes with each work sample is intended to help make sense of why the work shows how good is good enough. The commentary explains the task on which the student worked and the circumstances under which the work was completed, and draws attention to the qualities of the work with direct reference to the performance descriptions for the relevant standards.

The commentary also notes our reservations about the work.

The commentary also draws attention to any reservations we have about the student work.

In all cases, the work samples are genuine student work. While they provide valuable platforms from which to illustrate aspects of the standards, many samples are not "perfect" in every respect. Some, for example, include spelling errors, clumsy grammatical constructions, or errors of calculation. We think it is important that the standards be illustrated by means of authentic work samples and accordingly have made no attempt to doctor the work in order to correct these imperfections: the work has been included "warts and all". Where errors occur, we have included a note drawing attention to the nature of the mistakes and commenting on their significance in the context of the work. In some cases, for example, the work was produced as a first draft only (in which case it would be expected that the errors would be corrected in work presented as finished work), or produced by a student with limited English language proficiency, or there is evidence in the rest of the work to suggest that the error was a slip rather than an error in conceptual understanding.

In other words, we have tried to adopt reasonable expectations for correctness, but not to overlook errors where they arise. We have also resolved to apply those expectations consistently to all the work samples. We have paid attention to spelling, for example, not only in the work samples included to illustrate the English Language Arts standards, but also in those samples included to illustrate standards in the other subject areas. Similarly, we are also reviewing all work samples for accuracy in relation to mathematical and scientific content.

Performance Standards = performance descriptions + work samples + commentaries on the work samples.

Performance standards are therefore made up of a combination of performance descriptions, work samples, and commentaries on the work samples:

The performance descriptions tell what students should know and be able to do.

The work samples show what work that is judged good enough looks like.

The commentaries explain why the work is good enough with reference to the performance description.

A work sample may illustrate more than one standard.

Often the work samples illustrate the quality of work expected for more than one standard. For example, some of the work samples selected to illustrate parts of the Writing standard also illustrate expectations for the Conventions standard, or for the Literature standard, or possibly even both.

"All Quiet on the Western Front" (see page 30) is an example of a work sample that illustrates more than one standard in English Language Arts.

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How to Read These Standards

A single work sample may illustrate standards from more than one subject area.

Similarly, a single work sample may illustrate standards drawn from more than one subject area. For example, a project completed for Mathematics Standard 8, Putting Mathematics to Work, may also illustrate the report writing part of English Language Arts Standard 2, Writing. It may also qualify as a project within the requirements of Applied Learning Standard 1, Problem Solving.

"Who? Me? Pollute?" (see page 86) is an example of a work sample that illustrates standards from more than one subject area.

Standards are highlighted in the bar at the top of the page.

The bar along the top of the pages showing student work highlights the standards that are illustrated by each work sample.

World class connections provide a basis for comparison.

On most pages showing work samples and commentaries we have included an example of a standard, a portion of the curriculum, or a student activity drawn from material collected from other countries. These examples provide a basis for comparison with the performance standards. The full list of references from which these examples are drawn is shown on pages 124-125.

Not all standards are the same.

As you read these standards it will become apparent that the standards are not all the same. The most obvious difference is the way in which the performance descriptions are written. We have not imposed a single style on the ways in which the standards are written, because the various standards have different purposes that lend themselves to different kinds of presentation. Nevertheless, there are some patterns. We have identified three categories or kinds of standards, distinguished by their relationship to products of student learning and by the range of evidence required to demonstrate achievement of the standards. The distinctions are broad rather than neat, and we have sought only to define them generally rather than precisely.

The differences among the standards have consequences for what it means to meet a standard and, therefore, for the ways in which we can use samples of student work to illustrate what work that is good enough looks like.

Standards that describe a piece of work.

One kind of standard is characterized by the Writing standard in English Language Arts. Each part of this standard literally describes a piece of work that students are expected to produce, and the knowledge and skills that should be evident in that work. For this standard there is a one to one relationship between each part of the standard and a piece of work.

Standards that fit this category generally are:
English Language Arts Standards 1, 2, and 5;
Mathematics Standard 8;
Science Standard 8;
Applied Learning Standards 1, 2, and 5.

In the case of Mathematics Standard 8, Putting Mathematics to Work, Science Standard 8, Scientific Investigation, and Applied Learning Standard 1, Problem Solving, there is a one to one relationship between the standard as a whole and a piece of work.

Standards of this kind have several features:

- A single piece of work can meet the standard. In fact all of the requirements of the standard usually must be evident in a single piece of work for it to be judged as meeting the standard.
- The qualities that must be evident in a piece of work for it to meet the standard can be stated explicitly and are listed in bullet points as part of the bold-typed performance description. These qualities can be thought of as assessment criteria or as a rubric for work that meets the standard.

Commentaries make judgments about the whole piece of work.

Commentaries on work samples that illustrate these standards make judgments about the whole piece of work.

See, for example, "Compost Pile" on page 68.

Standards that focus exclusively on conceptual understanding.

A second kind of standard is characterized by Mathematics Standard 1, Number and Operation Concepts. This standard focuses exclusively on conceptual understanding.

Standards that fit this category generally are:
Mathematics Standards 1, 2, 3, and 4;
Science Standards 1, 2, 3, and 4.

These standards have several features:

- The standard comprises a number of distinct parts. It is most unlikely that any single piece of work will demonstrate all parts of the standard. In fact, it is common for a single piece of work to relate only to some aspects of one part of the standard. Thus, the standard can usually only be met by multiple pieces of work.

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- Conceptual understanding is developmental. Any one piece of work may contain elements of conceptual understanding that are below what is expected for the grade level and elements that either meet or exceed what is expected for the grade level. Judging whether the work is "up to standard" often means making an on-balance judgment. The developmental nature of conceptual understanding makes it difficult to specify in more than general terms the qualities that need to be pre sent in a piece of work for it to be judged as being up to standard for the grade level. These expectations are being defined concept by concept.

Commentaries are qualified by comments about further evidence needed.

Commentaries on work samples that illustrate these standards are qualified by comments about further evidence needed to demonstrate meeting the standard.

See, for example, "The Density of Sand" on page 58.

Standards that describe skills and tools.

The third kind of standard is characterized by English Language Arts Standard 3, Conventions, Grammar, and Usage of the English Language. It is made up of the standards that describe skills and tools, such as analytical skills.

Standards that fit this category generally are:
English Language Arts Standards 3 and 4;
Mathematics Standards 5, 6, and 7;
Science Standards 5, 6, and 7;
Applied Learning Standards 3 and 4.

What distinguishes these standards from the other kinds is the body of evidence needed to demonstrate that the standard has been met. In some cases it is possible that a single piece of work could provide evidence of all of the features required to meet the standard; this is so for the standard for Conventions, Grammar, and Usage of the English Language, for example. But it would be rare for a single piece of work to constitute sufficient evidence for meeting the standard. Here, sufficiency refers not only to the idea of coverage but also to a notion of consistency of application. We want to be confident that the work in question is representative of a body of work.

Ideally, work that provides evidence for these standards also provides evidence for other standards.

Commentaries are qualified by comments about further evidence needed.

Commentaries on work samples that illustrate these standards are qualified by comments about further evidence needed to demonstrate meeting the standard.

See, for example, "Designing a Theater" on page 52.

The collection of work samples is not complete.

In no case is the current collection of work samples adequate for the purpose of illustrating the performance standards.

Nor is the current collection of work samples yet adequate for the purpose of displaying a sufficient range of the ways in which students might produce work that illustrates the standards. We are making a deliberate effort to ensure that the overall collection of work samples is drawn from a diverse range of students. Given the role of the work samples in helping to articulate the meaning of the standards, it is critical that their content reflects the diversity of the cultures and experiences of the students for whom the standards are intended.

It is possible that, as the collection of work samples proceeds, some of the work samples currently included will be discarded in favor of others.

Some standards cannot be illustrated by written work samples.

Some standards are not illustrated here because they cannot be illustrated by written work samples. Obvious examples of these standards are English Language Arts Standard 3, Speaking, Listening, and Viewing and the oral presentation parts of Applied Learning Standard 2, Communication Tools and Techniques.

We are in the process of collecting samples of performances on videotape and will produce a videotape to complement this book containing work samples and commentaries focusing on oral work and other performances.

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Overview of the Performance Standards

English Language Arts

1. Reading
2. Writing
3. Speaking, Listening, and Viewing
4. Conventions, Grammar, and Usage of the English Language
5. Literature
6. Public Documents
7. Functional Documents

Mathematics

1. Number and Operation Concepts
2. Geometry and Measurement Concepts
3. Function and Algebra Concepts
4. Statistics and Probability Concepts
5. Problem Solving and Mathematical Reasoning
6. Mathematical Skills and Tools
7. Mathematical Communication
8. Putting Mathematics to Work

Science

1. Physical Sciences Concepts
2. Life Sciences Concepts
3. Earth and Space Sciences Concepts
4. Scientific Connections and Applications
5. Scientific Thinking
6. Scientific Tools and Technologies
7. Scientific Communication
8. Scientific Investigation

Applied Learning

1. Problem Solving
2. Communication Tools and Techniques
3. Information Technology Tools and Techniques
4. Learning and Self-management Tools and Techniques
5. Tools and Techniques for Working With Others

The high school standards are set at a level of performance approximately equivalent to the end of tenth grade. It is expected that some students might achieve this level earlier and others later than this grade.

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PERFORMANCE DESCRIPTIONS, WORK SAMPLES & COMMENTARIES

English Language Arts

Mathematics

Science

Applied Learning

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To see how these performance descriptions compare with the expectations for elementary school and middle school, turn to pages 96–101.

Samples of student work that help explain "how good is good enough" for these standards can be found immediately following these pages.

The reading requirement assumes an adequate library of appropriate reading material. In some places, library resources are too meager to support the amount of reading required for every student to achieve this standard. Where a shortage of books exists, better use of out-of-school resources must be made; for example, students may have to be assured access to local or county libraries.

Reading twenty-five books a year entails a substantial amount of time. Students may use materials read in conjunction with their regular class work, including courses other than English, to satisfy this requirement. A sample reading list appears on this page.

Reading "in depth" is intended to encourage students to invest themselves thoroughly in an area that interests them. Such an investment will generate reading from an array of resources, giving students more experience of reading as well as increased understanding of a subject. It is not intended to be some cursory experience of doing research on a topic which often requires little more than scanning materials, copying directly from references, and inserting transitional phrases and paragraphs. The challenge with the depth requirement is to encourage instead a complex understanding developed and enhanced through reading.

1. Reading

Reading is a process which includes demonstrating comprehension; analyzing and interpreting printed texts; making connections between parts of a text, among several texts, and between texts and other experiences in and out of school; making extensions and applications of a text; evaluating texts; generalizing beyond the text to a broader sample or concept; and identifying the textual structure and/or the rhetorical function of a text. (Note that "comprehension" means basic understanding, i.e., getting the gist of a text.)

The student reads and comprehends material of the quality and complexity illustrated in the sample reading list equivalent to twenty-five books each year. The materials should include traditional and contemporary literature or the equivalent in magazines, newspapers, textbooks, and media, from at least three different literary genres and from at least five different writers. The student produces evidence of reading that:

- **demonstrates a thorough understanding of the text as a whole;**
- **identifies complexities presented in the text, i.e., ideas, information, levels of meaning;**
- **extracts salient information from the text;**
- **uses paraphrasing judiciously.**

Examples of producing evidence of reading include:

- maintaining annotated lists of works read;
- generating reading logs or journals;
- participating in formal and informal book talks;
- creating an annotated book list for a reading group.

The student reads in depth at least four books (or book equivalents) about one issue or subject, or four books by a single writer, or four books in one genre, and produces evidence of reading that:

- **makes and supports warranted and responsible assertions about the texts;**
- **supports assertions with elaborated and convincing evidence;**
- **makes perceptive and well developed connections;**
- **evaluates writing strategies and elements of the author's craft.**

Examples of producing evidence of reading in depth include:

- constructing book reviews;
- producing literary response papers;
- producing research reports;
- participating in formal or informal book talks;
- creating an annotated book list organized according to author, theme, or genre.

The student reads informational materials to develop understanding and expertise and produces written or oral work that:

- **restates or summarizes information;**
- **relates new information to prior knowledge and experience;**
- **extends ideas;**
- **makes connections to related topics or information.**

Examples of producing evidence of reading informational materials include:

- using information to support or enhance a project;
- writing a report of information that draws from at least two sources;
- incorporating expert opinions into a speech or position paper;
- developing a proposal based on data obtained from reading informational texts;
- using informational materials to reach a conclusion regarding a controversial topic;
- developing a portfolio of materials regarding a particular career choice;
- writing exhibit notes for historical or artistic exhibits.

SAMPLE READING LIST

Sample reading list from which students and teachers could select. This list is not exclusive. Acceptable titles also appear on lists produced by organizations such as the National Council of Teachers of English and the American Library Association. Substitutions might also be made from lists approved locally.

Fiction

Brito, *The Devil in Texas;*
Carroll, *Alice in Wonderland;*
Cisneros, *The House on Mango Street;*
Clark, *The Ox-Bow Incident;*
Golding, *Lord of the Flies;*
Hawthorne, *The Scarlet Letter;*
Hemingway, *For Whom the Bell Tolls;*
Hentoff, *The Day They Came to Arrest the Book;*
Hilton, *Goodbye, Mr. Chips;*
Kinsella, *Shoeless Joe;*
Knowles, *A Separate Peace;*
Lee, *To Kill a Mockingbird;*
McCullers, *The Heart Is a Lonely Hunter;*
Orwell, *1984;*
Paulsen, *Canyons;*
Portis, *True Grit;*
Potok, *Davita's Harp;*
Steinbeck, *Travels With Charley in Search of America;*
Wartski, *A Boat to Nowhere;*
Welty, *The Golden Apples.*

Non-Fiction

Angell, *Late Innings;*
Angelou, *I Know Why the Caged Bird Sings;*
Ashe, *Days of Grace;*
Beal, *"I Will Fight No More Forever": Chief Joseph and the Nez Perce War;*
Bishop, *The Day Lincoln Was Shot;*
Bloom, *The Closing of the American Mind;*
Campbell, *The Power of Myth;*
Covey, *Seven Habits of Highly Effective People;*
Galarza, *Barrio Boy;*
Hawking, *A Brief History of Time;*
Houston, *Farewell to Manzanar;*
Kennedy, *Profiles in Courage;*
Kingsley and Levitz, *Count Us In: Growing Up With Down Syndrome;*
Kingston, *Woman Warrior;*
Mazer, ed., *Going Where I'm Coming From;*
Momaday, *The Way to Rainy Mountain;*
Rodriquez, *Hunger of Memory;*
Sternberg, *User's Guide to the Internet;*
Wright, *Black Boy.*

Poetry

Angelou, *I Shall Not be Moved;*
Bly, ed., *News of the Universe;*
Cummings, *Collected Poems;*
Dickinson, *Complete Poems;*
Randall, ed., *The Black Poets;*
Carruth, ed., *The Voice That Is Great Within Us;*
Hughes, *Selected Poems;*
Knudson and Swenson, eds., *American Sports Poems;*
Longfellow, *Evangeline;*
Wilbur, *Things of This World.*

Drama

Christie, *And Then There Were None;*
Hansberry, *A Raisin in the Sun;*
McCullers, *The Member of the Wedding;*
Pomerance, *The Elephant Man;*
Rose, *Twelve Angry Men;*
Rostand, *Cyrano de Bergerac;*
Shakespeare, *Romeo and Juliet, Julius Caesar;*
Van Druten, *I Remember Mama;*
Wilder, *The Skin of Our Teeth;*
Wilson, *The Piano Lesson.*

Folklore/Mythology

Evslin, *Adventures of Ulysses;*
Pinsent, *Greek Mythology;*
Stewart, *The Crystal Cave;*
Rutland, *North American Indian Mythology;*
White, *The Once and Future King.*

Modern Fantasy and Science Fiction

Adams, *Watership Down;*
Asimov, *Foundation;*
Bradbury, *The Martian Chronicles;*
Clarke, *2001: A Space Odyssey;*
Clarke, *Childhood's End;*
Frank, *Alas, Babylon;*
Herbert, *Dune;*
Lewis, *Out of the Silent Planet;*
McCaffrey, *Dragonflight;*
Twain, *A Connecticut Yankee in King Arthur's Court;*
Verne, *20,000 Leagues Under the Sea.*

Magazines and Newspapers

Omni;
Sports Illustrated;
Literary Cavalcade (Scholastic);
National Geographic;
Smithsonian;
Newsweek;
Time.

Other

Computer manuals; instructions; contracts; technical materials.

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2. Writing

Writing is a process through which a writer shapes language to communicate effectively in terms of purposes, audiences, and contexts.

The student produces six types of writing.

A report, in which the writer:
- **engages the reader by establishing a context, creating a persona, and otherwise developing reader interest;**
- **develops a controlling idea that conveys a perspective on the subject;**
- **creates an organizing structure appropriate to purpose, audience, and context;**
- **includes appropriate facts and details;**
- **excludes extraneous and inappropriate information;**
- **uses a range of appropriate strategies, such as providing facts and details, describing or analyzing the subject, narrating a relevant anecdote, comparing and contrasting, naming, explaining benefits or limitations, demonstrating claims or assertions, and providing a scenario to illustrate.**

Examples of reports include:
- an I-search essay;
- a saturation report;
- a report produced as part of studies in subjects such as Science, Social Studies, and Mathematics;
- a formal or informal research paper;
- an investigative report for a newspaper.

A response to literature, in which the writer:
- **engages the reader through establishing a context, creating a persona, and otherwise developing reader interest;**
- **advances a judgment that is interpretive, analytic, evaluative, or reflective;**
- **supports a judgment through references to the text, references to other works, authors, or non-print media, or references to personal knowledge;**
- **demonstrates understanding of the literary work through suggesting an interpretation;**
- **anticipates and answers a reader's questions;**
- **recognizes possible ambiguities, nuances, and complexities.**

Examples of responses to literature include:
- a literary response paper;
- a literary analysis;
- a book or movie review;
- an evaluation of a piece of literature or several pieces of literature;
- a comparison of a piece of literature with its media presentation;
- a response that focuses on personalizing the theme of a literary work;
- an analysis of the significance of a section of a novel in terms of its significance to the novel as a whole;
- an evaluation of the role played by setting in a novel;
- an analysis of the effect of a minor character on the plot of a novel;
- an interpretation of a recurring motif in a novel or a play;
- a comparison of two critical interpretations of a poem or a work of fiction.

A narrative account (fictional or autobiographical), in which the writer:
- **engages the reader by establishing a context, creating a point of view, and otherwise developing reader interest;**
- **establishes a situation, plot, point of view, setting, and conflict (and for autobiography, the significance of events and of conclusions that can be drawn from those events);**
- **creates an organizing structure;**
- **includes sensory details and concrete language to develop plot and character;**
- **excludes extraneous details and inconsistencies;**
- **develops complex characters;**
- **uses a range of appropriate strategies, such as dialogue, tension or suspense, naming, pacing, and specific narrative action, e.g., movement, gestures, expressions.**

Examples of narrative accounts include:
- an autobiographical account;
- a biographical account;
- a fiction or non-fiction story;
- a personal narrative;
- a narrative poem or song based on a modern hero;
- a historical account;
- a parody of a particular narrative style, e.g., fable, soap opera.

A narrative procedure, in which the writer:
- **engages the reader by establishing a context, creating a persona, and otherwise developing reader interest;**
- **provides a guide to action for a complicated procedure in order to anticipate a reader's needs; creates expectations through predictable structures, e.g., headings; and provides smooth transitions between steps;**
- **makes use of appropriate writing strategies, such as creating a visual hierarchy and using white space and graphics as appropriate;**
- **includes relevant information;**
- **excludes extraneous information;**
- **anticipates problems, mistakes, and misunderstandings that might arise for the reader.**

Examples of narrative procedures include:
- a set of rules for organizing a class meeting;
- a set of instructions for playing computer games;
- a set of instructions for using media technology;
- a lab report;
- a report of a mathematical investigation;
- a set of instructions for "logging on" to the Internet.

A persuasive essay, in which the writer:
- **engages the reader by establishing a context, creating a persona, and otherwise developing reader interest;**
- **develops a controlling idea that makes a clear and knowledgeable judgment;**
- **creates an organizing structure that is appropriate to the needs, values, and interests of a specified audience, and arranges details, reasons, examples, and anecdotes effectively and persuasively;**
- **includes appropriate information and arguments and excludes information and arguments that are irrelevant;**
- **anticipates and addresses reader concerns and counter arguments;**
- **supports arguments with detailed evidence, citing sources of information as appropriate;**
- **uses a range of strategies to elaborate and persuade, such as definitions, descriptions, illustrations, examples from evidence, and anecdotes.**

Examples of persuasive essays include:
- a position paper;
- a problem-solution paper;
- an opening statement for a debate;
- an evaluation of a product or service;
- a critique of a public policy;
- an editorial on a current issue that uses reasoned arguments to support an opinion.

A reflective essay, in which the writer:
- **engages the reader by establishing a context, creating a persona, and otherwise developing reader interest;**
- **analyzes a condition or situation of significance;**
- **develops a commonplace, concrete occasion as the basis for the reflection, e.g., personal observation or experience;**
- **creates an organizing structure appropriate to purpose and audience;**
- **uses a variety of writing strategies, such as concrete details, comparing and contrasting, naming, describing, creating a scenario.**

Examples of reflective essays include:
- an analysis of the significance of a proverb or quotation;
- a report about a concrete occasion and its implications over time;
- an essay comparing a school issue to broader societal concerns;
- a paper explaining how some experiences, conditions, or concerns have universal significance;
- a self-reflective essay evaluating a portfolio to be submitted;
- a comparison of a scene from a work of fiction with a lesson learned from a personal experience;
- a paper about a common childhood experience from a more adult perspective.

The "response to literature" in the Writing standard is meant to replace the more typical literary analysis paper that many students routinely produce in conjunction with literature study. This does not preclude literary analysis but instead opens up possibilities for reader response as well.

It is not intended that all student work developed to meet the English Language Arts standards should necessarily come from an English class. The challenge is to ensure that Mathematics, Science, and Applied Learning work samples are incorporated widely into the English Language Arts work samples, thus encouraging students to use work from other classes while not weakening the English curriculum.

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To see how these performance descriptions compare with the expectations for elementary school and middle school, turn to pages 96–101.

Samples of student work that help explain "how good is good enough" for these standards can be found immediately following these pages.

3. Speaking, Listening, and Viewing

The student accesses and exchanges information; that is, the student:

- **asks appropriate questions;**
- **responds to the questions of others;**
- **paraphrases and summarizes to increase understanding;**
- **listens responsively to others' points of view;**
- **uses language which is simple and appropriate for communicating;**
- **speaks audibly;**
- **makes appropriate eye contact;**
- **respects turn taking of other speakers;**
- **uses language and gestures expressively and persuasively;**
- **shows awareness of an audience by adjusting to its reaction.**

Examples of accessing and exchanging information include:

- researching, planning, and conducting an interview;
- demonstrating responsiveness to the questions of others by using varied "forms of support";
- making a formal report;
- explaining an abstract principle or operation to a younger student;
- organizing and conducting a public forum;
- presenting a briefing on an issue;
- formulating appropriate questions following a formal presentation;
- participating in a panel discussion;
- presenting a portfolio to an individual or panel and discussing strengths and weaknesses of the portfolio contents;
- participating in response groups as part of the writing process.

The student responds to oral presentations; that is, the student:

- **asks appropriate questions;**
- **paraphrases and summarizes to increase understanding;**
- **speaks audibly;**
- **uses language and gestures expressively and persuasively.**

Examples of responding to oral presentations include:

- analyzing argumentation and types of appeals in public policy speeches;
- evaluating the credibility and probability of evidence used in a presentation;
- engaging in debate;
- asking appropriate follow up questions;
- exploring the characteristics of effective listening and developing criteria by which to assess a presentation.

The student makes informed judgments about television, radio, and film productions; that is, the student:

- **articulates reasoned judgments for selecting particular television and radio programs and rejecting others;**
- **recounts the story elements of television, radio, and film productions;**
- **identifies the intended messages of advertisements, entertainment programs, and news programs;**
- **identifies the common persuasive techniques used in advertising;**
- **describes ways used to portray and comment on the general culture;**
- **demonstrates an understanding of media stereotyping and other socially significant portrayals;**
- **understands the effects of media production techniques on viewers' perceptions, including the use of music, camera angles, fade-outs.**

Examples of making informed judgments about television, radio, and film productions include:

- helping to produce a single story, e.g., a contemporary folk tale, across several media, e.g., video, radio, print;
- producing a documentary video;
- analyzing television programming and advertising patterns across a period of time;
- writing a review of a television program or film;
- creating a story board for a television commercial;
- writing an original television script;
- videotaping an interview with a prominent local or school official.

4. Conventions, Grammar, and Usage of the English Language

The student independently and habitually uses the appropriate conventions of the English language, including:

- **spelling;**
- **sentence construction;**
- **paragraph structure;**
- **punctuation;**
- **grammar;**
- **usage.**

Examples of using appropriate conventions include:

- demonstrating in a piece of writing the ability to manage the conventions, grammar, and usage of English so that they aid rather than interfere with reading;
- proofreading independently and accurately the student's own writing or the writing of others, using dictionaries, thesauruses, and other resources as appropriate;
- observing the conventions of language during formal oral presentations;
- demonstrating use of a variety of sentence patterns for stylistic effect.

The student analyzes and revises written work, as appropriate, relative to audiences and purposes by:

- **adding or deleting details;**
- **adding or deleting explanations;**
- **clarifying difficult passages;**
- **rearranging words, sentences, and paragraphs to improve or clarify meaning;**
- **sharpening the focus;**
- **reconsidering the organizational structure.**

Examples of analyzing and revising written work include:

- incorporating into revised drafts, as appropriate, suggestions taken from critiques made by peers and teachers;
- producing a series of distinctly different drafts that result in a polished piece of writing;
- critiquing the writing of a peer;
- describing the reasons for stylistic choices made as a writer;
- producing a series of papers on the same topic, each serving a different purpose;
- demonstrating how to change the presentation of a topic for different audiences.

5. Literature

The student responds to fiction, non-fiction, poetry, and drama using interpretive, critical, and evaluative processes; that is, the student does one or more of the following in oral and written presentations:

- **makes inferences and draws conclusions about content, events, characters, setting, theme, and style;**
- **interprets the effect of literary devices, such as figurative language, allusion, diction, dialogue, description, symbolism;**
- **evaluates the impact of authors' decisions regarding word choice, style, content, and literary elements;**
- **analyzes the characteristics of literary forms and genres;**
- **evaluates literary merit;**
- **explains the effect of point of view;**
- **makes thematic connections among literary texts, public discourse, and media;**
- **interprets ambiguities, subtleties, contradictions, ironies, and nuances;**
- **demonstrates how literary works reflect the period which shaped them.**

Examples of responding to literature include:

- analyzing stereotypical characters in popular fiction;
- evaluating the effect of literary devices in a number of poems by one author or poems on a common topic;
- comparing the literary merits of two or more short stories, biographies of one individual, novels, or plays;
- comparing two different video presentations of a literary work;
- comparing two works written in different time periods on the same topic or theme;
- evaluating the persona of the writer;
- analyzing the literary, cultural, and social context of a literary work.

The student demonstrates proficiency in at least one literary genre.

Examples of literary genres include:

- a reflective essay;
- a short story;
- a short play;
- poetry, e.g., free verse and rhymed;
- a vignette.

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6. Public Documents

A public document is a document that has at least one of the following purposes: to take issue with a contemporary public policy and suggest an alternative course of action; to analyze and defend a contemporary public policy; to define a public problem and suggest policy.

The student produces at least one public document, in which the writer:

- **exhibits an awareness of the importance of precise word choice and the power of imagery and/or anecdote;**
- **utilizes and recognizes the power of logical arguments, arguments based on appealing to a reader's emotions, and arguments dependent upon the writer's persona;**
- **uses arguments that are appropriate in terms of the knowledge, values, and degree of understanding of the intended audience;**
- **uses a range of strategies to appeal to readers.**

Examples of public documents include:

- a proposal for changing an existing social or school policy;
- an analysis of a state policy;
- a policy statement that closely examines a significant public policy and proposes a change;
- a letter to an elected official taking a position on an issue or concern;
- a press release announcing a policy.

The student critiques at least one public document, with an eye to strategies common in public discourse, including:

- **effective use of argument;**
- **use of the power of anecdote;**
- **anticipation of counter claims;**
- **appeal to audiences both friendly and hostile to the position presented;**
- **use of emotionally laden words and imagery;**
- **citing of appropriate references or authorities.**

Examples of critiquing public documents include:

- analyzing a political speech;
- evaluating an editorial;
- examining campaign literature to determine underlying assumptions;
- examining a range of articles published in a magazine or newspaper and drawing inferences about the political stance of that magazine or newspaper.

7. Functional Documents

A functional document is a document that exists in order to get things done.

The student produces at least one functional document, appropriate to audience and purpose, in which the writer:

- **reports, organizes, and conveys information and ideas accurately;**
- **includes relevant narrative details, such as scenarios, definitions, examples;**
- **anticipates readers' problems, mistakes, and misunderstandings;**
- **uses a variety of formatting techniques, including headings, subordinate terms, foregrounding of main ideas, hierarchical structures, graphics, and color;**
- **establishes a persona that is consistent with the document's purpose;**
- **employs word choices that are consistent with the persona and appropriate for the intended audience.**

Examples of functional documents include:

- a summary of a meeting;
- a brochure;
- a proposal;
- a set of instructions;
- a recommendation.

The student critiques at least one functional document, with an eye to strategies common to good functional documents, including:

- **visual appeal, e.g., format, graphics, white space, headers;**
- **logic of the sequence in which the directions are given;**
- **awareness of possible reader misunderstandings.**

Examples of critiquing functional documents include:

- analyzing a manual;
- analyzing a contract;
- evaluating a loan application;
- critiquing tax documents.

These standards allow for oral performances of student work whenever appropriate.

Much writing can be classified as belonging to the public arena. At high school, students should address issues which are of national importance.

Functional writing is ordinarily considered technical writing and, as such, is often not part of the typical English curriculum. New Standards requires students to demonstrate proficiency with functional writing because such writing is of increasing importance to the complex literacy of our culture.

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Work Sample & Commentary: *Romanticism and Realism*

1 Reading	**2 Writing**	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	**5 Literature**	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech Tools & Techniques	4 Learning & Self-mgmt Tools & Techniques	Tools & Techniques for Working With Others

Applied Learning

English Language Arts required by the task

Students were asked to use class notes, personal knowledge, and several pieces of text—"The Road to Total War," "The Battle Hymn of the Republic," "Occurrence at Owl Creek Bridge"—to prove accurate Churchill's assessment that the American Civil War was "the last romantic war and the first horrendous modern war."

Circumstances of performance

✓	timed assignment
	extended project
	opportunity for revision
✓	first draft
	revised draft
✓	teacher generated topic
	student generated topic
✓	embedded in class work
✓	research required

This work sample provides evidence for the quality of work expected for the following parts of the English Language Arts standards:

Standard 2, Writing—produces a response to literature;

Standard 5, Literature—responds to fiction, non-fiction, poetry, and drama.

Writing

The student produces:

A response to literature, in which the writer:

- **engages the reader through establishing a context, creating a persona, and otherwise developing reader interest;**
- **advances a judgment that is interpretive, analytic, evaluative, or reflective;**
- **supports a judgment through references to the text, references to other works, authors, or non-print media, or references to personal knowledge;**
- **demonstrates understanding of the literary work through suggesting an interpretation;**
- **anticipates and answers a reader's questions;**
- **recognizes possible ambiguities, nuances, and complexities.**

This work provides evidence that the student:

- engages the reader by creating a persona, e.g., by restating the question as an introduction, which is appropriate because the audience for such an examination question is the teacher;
- advances a number of judgments and then supports them with references to textual material, e.g., "The song, 'The Battle Hymn of the Republic,' shows the civilians [sic] romantic attitude about war"; "William Sherman, considered the first modern general, had a very realistic perspective on war. He stated…";
- makes connections to broader issues by looking at the ramifications of Civil War mentality for those who live in the twentieth century, e.g., "Instead of learning from the Civil War, we have just followed and reformed the tactics we used there";
- recognizes the complexity of the terms being used, e.g., paragraph three begins by saying that "Towards the end of the war it turned very modern and realistic," and then later specifies what is meant by "realistic": "This [realistic perspective] is demonstrated because it shows how war went beyond the battlefields when a man was hanged for interfering with the war."

Literature

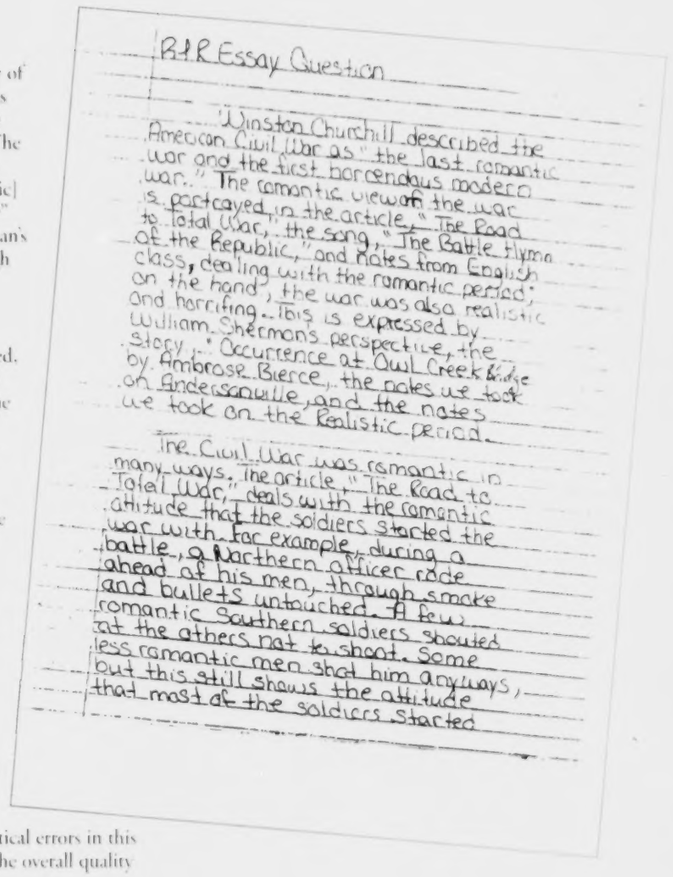
The student responds to fiction, non-fiction, poetry, and drama using interpretive, critical, and evaluative processes; that is, the student does one or more of the following in oral and written presentations:

- **makes inferences and draws conclusions about content, events, characters, setting, theme, and style;**
- **interprets the effect of literary devices, such as figurative language, allusion, diction, dialogue, description, symbolism;**
- **evaluates the impact of authors' decisions regarding word choice, style, content, and literary elements;**
- **analyzes the characteristics of literary forms and genres;**
- **evaluates literary merit;**
- **explains the effect of point of view;**
- **makes thematic connections among literary texts, public discourse, and media;**
- **interprets ambiguities, subtleties, contradictions, ironies, and nuances;**
- **demonstrates how literary works reflect the period which shaped them.**

This work provides evidence that the student:

- makes inferences about a variety of texts, i.e., an article, a song, class notes, a short story, and a single quotation, in suggesting that "The song, 'The Battle Hymn of the Republic,' shows the civilians [sic] romantic attitude about the war" [p. 2]; and in attributing Sherman's decision to burn his way through the South to his "very realistic perspective on war" [p. 2];
- makes thematic connections among the various texts discussed, e.g., "Also the notes we took on the Romantic Period tie in to the romantic view of the war. The Romantic Period…affected the civilians [sic] view because during the Romantic period idealism and the desire to escape unpleasant reality are two elements that also showed up in wartime" [p. 2].

Errors in this first draft, e.g., the use of "the civilians romantic attitude" instead of "civilian's," may be attributed to the nature of the task, which was given in a timed writing situation. The writing was completed in forty-five minutes with no opportunities for review and revision. The spelling and grammatical errors in this work sample do not detract from the overall quality of the work.



R&R Essay Question

"Winston Churchill described the American Civil War as "the last romantic war and the first horrendous modern war." The romantic view on the war is portrayed in the article "The Road to Total War," the song, "The Battle Hymn of the Republic," and notes from English class, dealing with the romantic period; on the hand, the war was also realistic and horrifing. This is expressed by William Sherman's perspective, the story "Occurrence at Owl Creek Bridge" by Ambrose Bierce, the notes we took on Andersonville, and the notes we took on the Realistic period.

The Civil War was romantic in many ways. The article "The Road to Total War," deals with the romantic attitude that the soldiers started the war with. For example, during a battle, a Northern officer rode ahead of his men, through smoke and bullets untouched. A few romantic Southern soldiers shouted at the others not to shoot. Some less romantic men shot him anyways, but this still shows the attitude that most of the soldiers started

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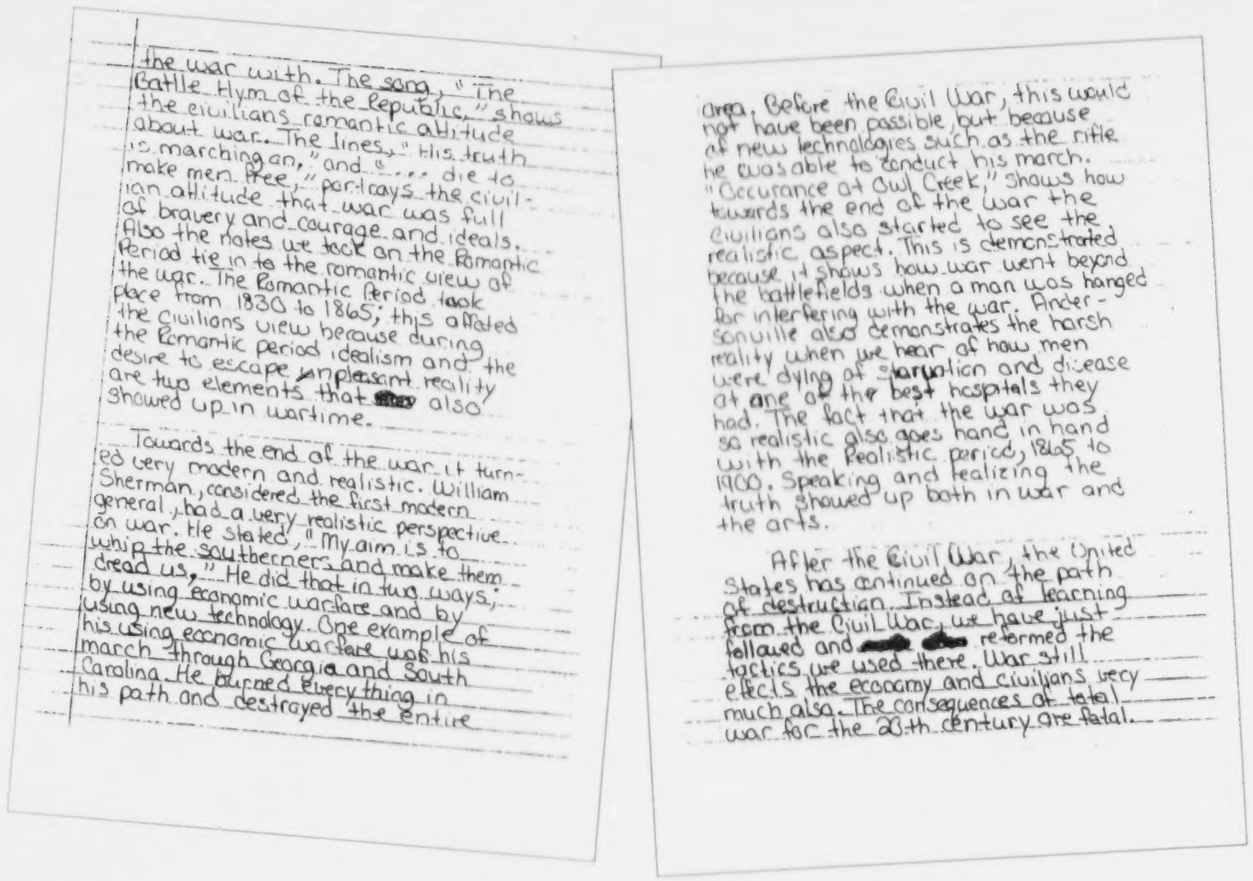

the war with. The song, "The Battle Hym of the Republic," shows the civilians romantic attitude about war. The lines," His truth is marching on," and "..... die to make men free," portrays the civilian attitude that war was full of bravery and courage and ideals. Also the notes we took on the Romantic Period tie in to the romantic view of the war. The Romantic Period took place from 1830 to 1865; this affated the civilians view because during the Romantic period idealism and the desire to escape unpleasant reality are two elements that [redacted] also showed up in wartime.

Towards the end of the war it turned very modern and realistic. William Sherman, considered the first modern general, had a very realistic perspective on war. He stated, "My aim is to whip the southerners and make them dread us," He did that in two ways, by using economic warfare and by using new technology. One example of his using economic warfare was his march through Georgia and South Carolina. He burned every thing in his path and destroyed the entire area. Before the Civil War, this would not have been possible, but because of news technologies such as the rifle he was able to conduct his march. "Occurance at Owl Creek," shows how towards the end of the war the civilians also started to see the realistic aspect. This is demonstrated because it shows how war went beyond the battlefields when a man was hanged for interfering with the war. Andersonville also demonstrates the harsh reality when we hear of how men were dying of starvation and disease at one of the best hospitals they had. The fact that the war was so realistic also goes hand in hand with the Realistic period, 1865 to 1900. Speaking and realizing the truth showed up both in war and the arts.

After the Civil War, the United States has continued on the path of destruction. Instead of learning from the Civil War, we have just followed and [redacted] reformed the tactics we used there. War still effects the economy and civilians very much also. The consequences of total war for the 20th century are fatal.

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Students in New Zealand are expected to "write regularly and confidently to respond to a range of experiences, ideas, observations, and texts, developing a personal voice."

English in the New Zealand Curriculum, p. 100.

Work Sample & Commentary: *Two Poems About Sports*

1 Reading	**2 Writing**	3 Speaking, Listening & Viewing	**4 Conventions, Grammar & Usage**	**5 Literature**	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech Tools & Techniques	4 Learning & Self-mgmt Tools & Techniques	5 Tools & Techniques for Working With Others

Applied Learning

English Language Arts required by the task

Students were asked to discuss the meaning they found in two poems and to justify or explain how they arrived at such a meaning.

Circumstances of performance

✓	timed assignment
	extended project
	opportunity for revision
✓	first draft
	revised draft
✓	teacher generated topic
	student generated topic
	embedded in class work
	research required

This work sample provides evidence for the quality of work expected for the following parts of the English Language Arts standards:

Standard 2, Writing—produces a response to literature;

Standard 4, Conventions, Grammar, and Usage of the English Language—uses appropriate conventions;

Standard 5, Literature—responds to poetry.

Writing

The student produces:

A response to literature, in which the writer:

- **engages the reader through establishing a context, creating a persona, and otherwise developing reader interest;**
- **advances a judgment that is interpretive, analytic, evaluative, or reflective;**
- **supports a judgment through references to the text, references to other works, authors, or non-print media, or references to personal knowledge;**
- **demonstrates understanding of the literary work through suggesting an interpretation;**
- **anticipates and answers a reader's questions;**
- **recognizes possible ambiguities, nuances, and complexities.**

This work provides evidence that the student:

- engages the reader by establishing a context, citing both the titles of the two poems being considered and the shared content, e.g., "the fickleness of sport success and celebrity";
- advances an interpretive judgment through reference to the texts, e.g., "Smart lad, to slip betimes away…" and "he dribbles an inner tube;/But most of us remember anyway";
- analyzes the author's craft and interprets both poems in terms of mood, e.g., "melancholy"; and in terms of attitude, e.g., "he/she is addressing the grave or the young athlete's spirit" and "The author sounds as though he were telling a story… making nostalgic conversation";
- recognizes nuances that are reflected in symbols, e.g., "the prized laurel wreath of victory"; and in common themes, e.g., "turning towards the past" and "equating past with present."

Literature

The student responds to fiction, non-fiction, poetry, and drama using interpretive, critical, and evaluative processes; that is, the student does one or more of the following in oral and written presentations:

- **makes inferences and draws conclusions about content, events, characters, setting, theme, and style;**
- **interprets the effect of literary devices, such as figurative language, allusion, diction, dialogue, description, symbolism;**
- **evaluates the impact of authors' decisions regarding word choice, style, content, and literary elements;**
- **analyzes the characteristics of literary forms and genres;**
- **evaluates literary merit;**
- **explains the effect of point of view;**
- **makes thematic connections among literary texts, public discourse, and media;**
- **interprets ambiguities, subtleties, contradictions, ironies, and nuances;**
- **demonstrates how literary works reflect the period which shaped them.**

This work provides evidence that the student:

- makes the inference that each poem focuses on the past and yet has a distinct tie to the present [par. 4 including the asterisk-marked portion];
- interprets the effect of literary devices, e.g., "Indeed, the rhyme scheme is such that…it produces a sort of funeral-march rhythm, steady and slow."

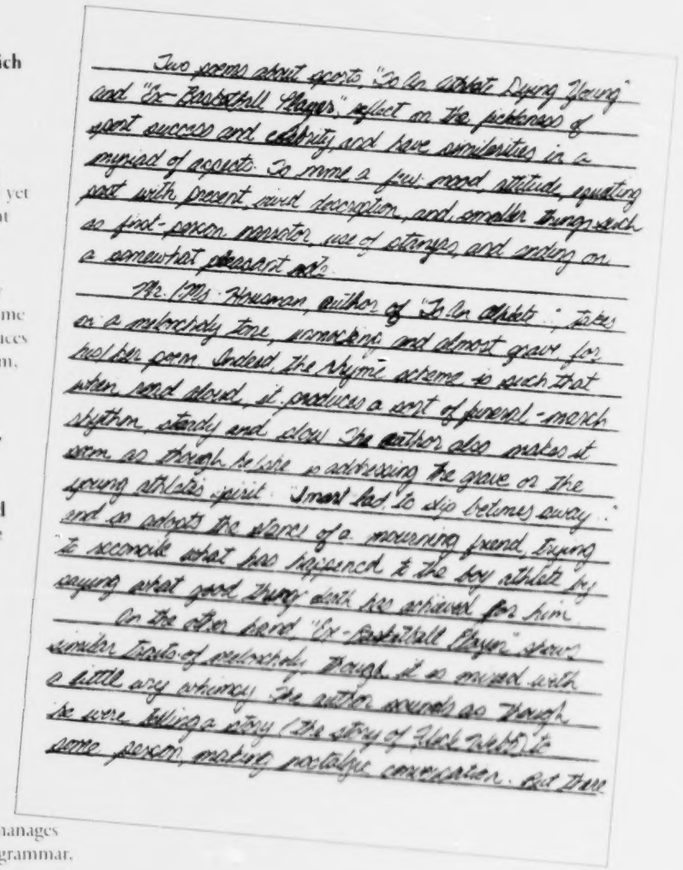
Conventions, Grammar, and Usage of the English Language

The student independently and habitually uses the appropriate conventions of the English language, including:

- **spelling;**
- **sentence construction;**
- **paragraph structure;**
- **punctuation;**
- **grammar;**
- **usage.**

This work provides evidence that the student:

- in almost error free writing, manages spelling, punctuation, usage, grammar, and sentence structure.



Two poems about sports "To an Athlete Dying Young" and "To Basketball Players" reflect on the paradoxes of sport success and celebrity and have similarities in a myriad of aspects. To name a few, mood, attitude, equating past with present, word description, and somber tongue, as first-person narrator, use of strategies, and ending on a somewhat pessimistic note.

The 1896 Housman author of "To an Athlete" takes on a melancholy tone, somber and almost grave for most the poem. Indeed the rhyme scheme is such that when read aloud, it produces a sort of funeral-march rhythm, steady and slow. The author also makes it seem as though he/she is addressing the grave or the young athlete's spirit. Smart lad to slip betimes away: and so reports the stance of a mourning friend. Trying to reconcile what has happened to the boy athlete by saying what good things each has achieved for him. On the other hand "To Basketball Players" shows similar traits of melancholy though it is covered with a little wry whimsy. The author sounds as though he were telling a story (the story of Black Beauty) to some person making nostalgic conversation. But then

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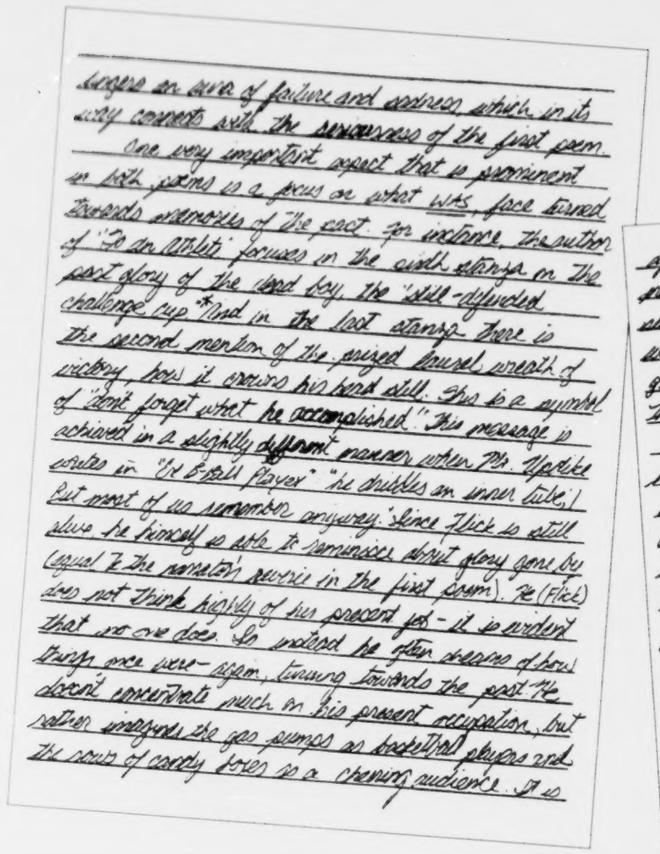

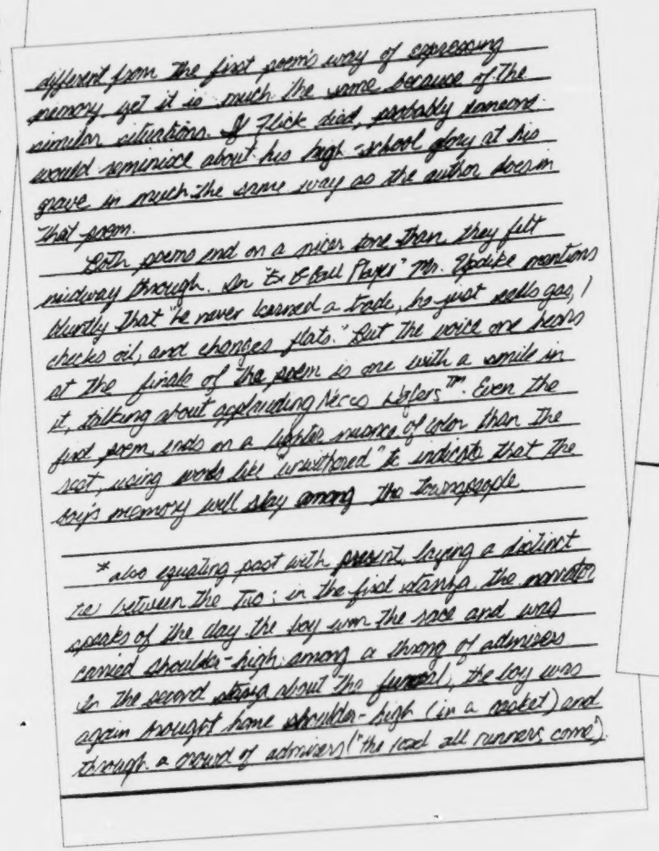

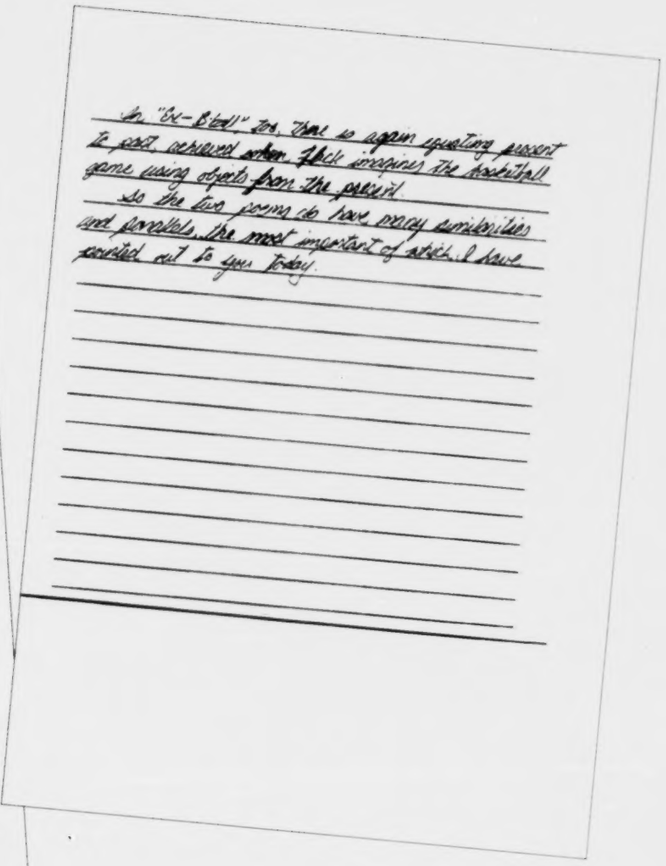

Students in England preparing for the General Certificate of Secondary Education "must demonstrate in writing that they can: write about their experience(s) and express what they feel and imagine;...show a sense of audience and an awareness of style in a variety of situations;...understand and appreciate choices which writers, including themselves, may make in language, structure and form to achieve the effects they want."

English: General Certificate of Secondary Education, National Curriculum Syllabus, 1994 examinations, Southern Examining Group.

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Work Sample & Commentary: *Cardboard Sax*

1 Reading	**2 Writing**	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech Tools & Techniques	4 Learning & Self-mgmt Tools & Techniques	5 Tools & Techniques for Working With Others

Applied Learning

English Language Arts required by the task

Students were asked to write about a memorable event in their lives and to include both the significance of the event and adequate details so readers could understand the importance of the event.

Circumstances of performance

✓	timed assignment
	extended project
	opportunity for revision
✓	first draft
	revised draft
	teacher generated topic
✓	student generated topic
	embedded in class work
	research required

This work sample provides evidence for the quality of work expected for the following part of the English Language Arts standards:

Standard 2, Writing—produces a narrative account.

Writing

The student produces:

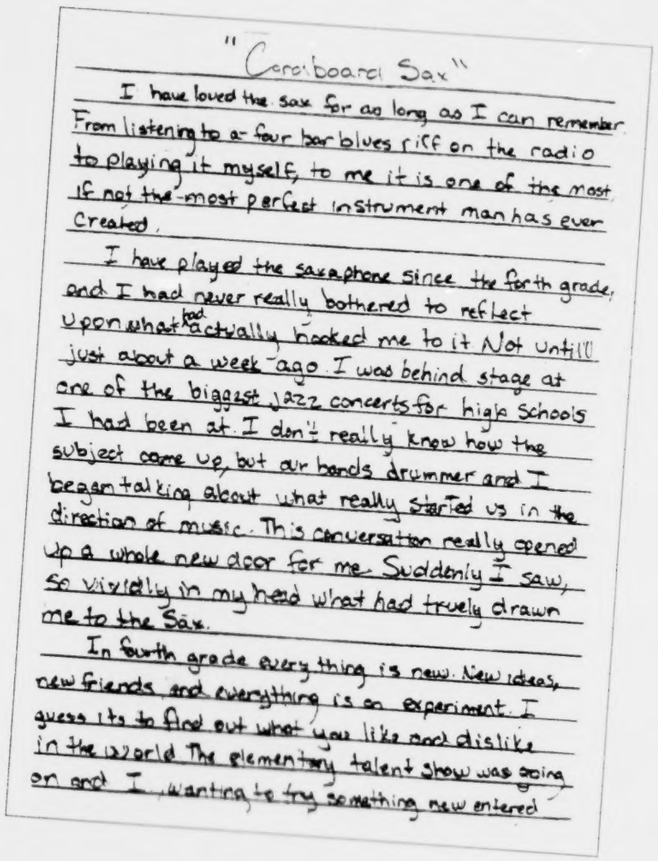
A narrative account (fictional or autobiographical), in which the writer:

- **engages the reader by establishing a context, creating a point of view, and otherwise developing reader interest;**
- **establishes a situation, plot, point of view, setting, and conflict (and for autobiography, the significance of events and of conclusions that can be drawn from those events);**
- **creates an organizing structure;**
- **includes sensory details and concrete language to develop plot and character;**
- **excludes extraneous details and inconsistencies;**
- **develops complex characters;**
- **uses a range of appropriate strategies, such as dialogue, tension or suspense, naming, pacing, and specific narrative action, e.g., movement, gestures, expressions.**

This work provides evidence that the student:

- engages the reader with a striking title and well crafted introduction: "I have loved the sax…the most perfect instrument man has ever created";
- establishes a situation by narrating a specific incident and explaining why the incident is both memorable and significant, i.e., the powerful effects resulting from playing a cardboard saxophone during a fourth grade talent show;
- creates a unifying structure with the significance of the incident, e.g., "This was the turning point of my life…and I have never been happier";
- excludes extraneous details and inconsistencies;
- uses a range of appropriate narrative strategies by setting a scene, e.g., "It was the hour before [the] performance…"; providing clear descriptions, e.g., the cardboard sax was "about as long as my arm, made from toilet paper rolls and paper towell [sic] rolls. At the end was a card board funnel"; and creating a high point in the narrative, e.g., "I took a running start—slid on my knees and grabbed the sax. [T]hroughout that solo, the world left me, and I saw nothing."

Errors in this first draft may be attributed to the nature of the task, which was given in a timed writing situation. The writing was completed in forty-five minutes with no opportunities for review and revision. The spelling and grammatical errors in this work sample do not detract from the overall quality of the work.



"Cardboard Sax"

I have loved the sax for as long as I can remember From listening to a four bar blues riff on the radio to playing it myself, to me it is one of the most if not the most perfect instrument man has ever created.

I have played the saxaphone since the forth grade, and I had never really bothered to reflect upon what actually hooked me to it Not until just about a week ago. I was behind stage at one of the biggest jazz concerts for high schools I had been at. I don't really know how the subject came up, but our bands drummer and I began talking about what really started us in the direction of music. This conversation really opened up a whole new door for me. Suddenly I saw, so vividly in my head what had truely drawn me to the Sax.

In fourth grade every thing is new. New ideas, new friends, and everything is an experiment. I guess its to find out what you like and dislike in the world. The elementary talent show was going on and I, wanting to try something new entered

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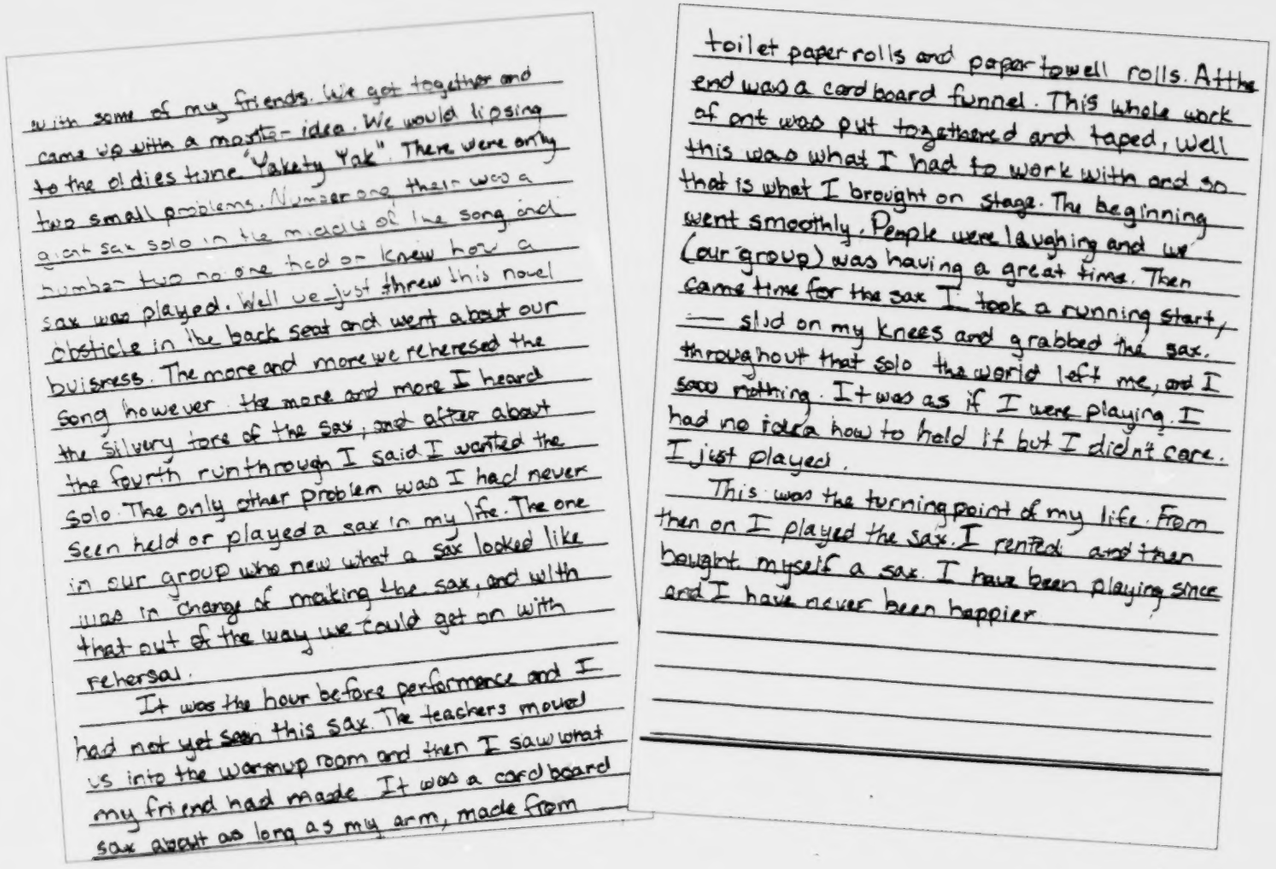

with some of my friends. We got together and came up with a master- idea. We would lipsing to the oldies tune "Yakety Yak". There were only two small problems. Number one there was a giant sax solo in the middle of the song and number two no one had or knew how a sax was played. Well we just threw this novel obsticle in the back seat and went about our buisness. The more and more we rehersed the song however the more and more I heard the silvery tone of the sax, and after about the fourth run through I said I wanted the solo. The only other problem was I had never seen held or played a sax in my life. The one in our group who new what a sax looked like was in charge of making the sax, and with that out of the way we could get on with rehersal.

It was the hour before performance and I had not yet seen this sax. The teachers moved us into the warmup room and then I saw what my friend had made. It was a cardboard sax about as long as my arm, made from toilet paper rolls and paper towell rolls. At the end was a cardboard funnel. This whole work of art was put togetherand taped, Well this was what I had to work with and so that is what I brought on stage. The beginning went smoothly. People were laughing and we (our group) was having a great time. Then came time for the sax I took a running start, — slid on my knees and grabbed the sax. throughout that solo the world left me, and I saw nothing. It was as if I were playing. I had no idea how to hold it but I didn't care. I just played.

This was the turning point of my life. From then on I played the sax. I rented and then bought myself a sax. I have been playing since and I have never been happier

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Australian students are expected to use "a variety of text types for writing about familiar or accessible subjects and exploring challenging ideas and issues; evident when students, for example, write about personal experiences...with attention to detail, consciously using narrative structures to involve readers."

English—a curriculum profile for Australian schools, p. 106.

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Work Sample & Commentary: *School Bond Levy*

1 Reading	**2 Writing**	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech Tools & Techniques	4 Learning & Self-mgmt Tools & Techniques	5 Tools & Techniques for Working With Others

Applied Learning

English Language Arts required by the task

Students were asked to write a persuasive essay based on research.

Circumstances of performance

	timed assignment
	extended project
✓	opportunity for revision
	first draft
✓	revised draft
	teacher generated topic
✓	student generated topic
	embedded in class work
✓	research required

This work sample provides evidence for the quality of work expected for the following parts of the English Language Arts standards:

Standard 2, Writing—produces a persuasive essay;
Standard 4, Conventions, Grammar, and Usage of the English Language—uses appropriate conventions.

Writing

The student produces:

A persuasive essay, in which the writer:

- **engages the reader by establishing a context, creating a persona, and otherwise developing reader interest;**
- **develops a controlling idea that makes a clear and knowledgeable judgment;**
- **creates an organizing structure that is appropriate to the needs, values, and interests of a specified audience, and arranges details, reasons, examples, and anecdotes effectively and persuasively;**
- **includes appropriate information and arguments and excludes information and arguments that are irrelevant;**
- **anticipates and addresses reader concerns and counter arguments;**
- **supports arguments with detailed evidence, citing sources of information as appropriate;**
- **uses a range of strategies to elaborate and persuade, such as definitions, descriptions, illustrations, examples from evidence, and anecdotes.**

This work provides evidence that the student:

- engages the reader by establishing a context, e.g., identifies facilities that the bond levy will add or improve and takes a clear stand on the issue; and by creating a consistent persona, i.e., that of a serious, reasonable individual willing to address reasonable opposing points of view;
- organizes the argumentative structure in light of an audience of adults who are concerned with accelerating tax levies, e.g., paragraph three deals with costs by detailing the actual dollar amount needed and by arguing that current low interest rates and expenses make additions and repairs more cost effective today than they will be in the future;
- excludes information and arguments that are irrelevant;
- anticipates reader concerns about the need for repairs by recounting in detail the results of a heating system failure and the unsafe conditions in the library;
- supports arguments with clear, detailed evidence, e.g., provides an account of the total costs and the results of Ballot Measure 5 and cites scheduling difficulties resulting from having only one gym; and with illustrations, e.g., shows why more space is needed;
- cites sources of information to help persuade the audience, e.g., the superintendent and science teachers;
- uses an effective strategy by closing the argument with an appeal to an emotional issue: "If the school is inadequate, how can the younger generations be provided with the education and training they need to be successful in the future?"

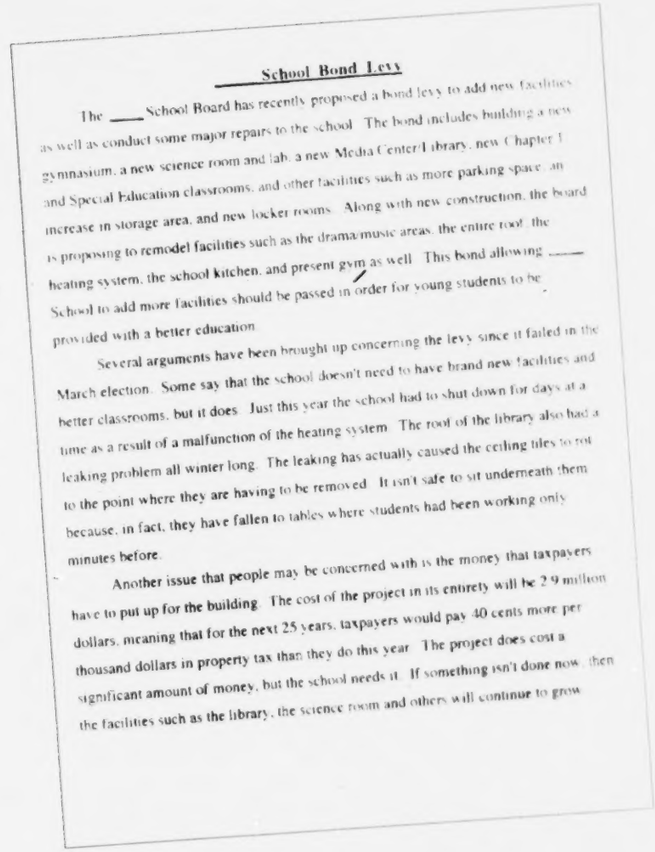
Conventions, Grammar, and Usage of the English Language

The student independently and habitually uses the appropriate conventions of the English language, including:

- **spelling;**
- **sentence construction;**
- **paragraph structure;**
- **punctuation;**
- **grammar;**
- **usage.**

This work provides evidence that the student:

- in almost error free writing, manages grammar, usage, spelling, punctuation, sentence construction, and paragraph structure.



School Bond Levy

The ___ School Board has recently proposed a bond levy to add new facilities as well as conduct some major repairs to the school. The bond includes building a new gymnasium, a new science room and lab, a new Media Center/Library, new Chapter 1 and Special Education classrooms, and other facilities such as more parking space, an increase in storage area, and new locker rooms. Along with new construction, the board is proposing to remodel facilities such as the drama/music areas, the entire roof, the heating system, the school kitchen, and present gym as well. This bond allowing ___ School to add more facilities should be passed in order for young students to be provided with a better education.

Several arguments have been brought up concerning the levy since it failed in the March election. Some say that the school doesn't need to have brand new facilities and better classrooms, but it does. Just this year the school had to shut down for days at a time as a result of a malfunction of the heating system. The roof of the library also had a leaking problem all winter long. The leaking has actually caused the ceiling tiles to rot to the point where they are having to be removed. It isn't safe to sit underneath them because, in fact, they have fallen to tables where students had been working only minutes before.

Another issue that people may be concerned with is the money that taxpayers have to put up for the building. The cost of the project in its entirety will be 2.9 million dollars, meaning that for the next 25 years, taxpayers would pay 40 cents more per thousand dollars in property tax than they do this year. The project does cost a significant amount of money, but the school needs it. If something isn't done now, then the facilities such as the library, the science room and others will continue to grow

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steadily worse. The construction and remodeling needs to be done eventually, so why not now, when interest rates are low and expenses are also low. Superintendent ___ commented that it would cost the taxpayers much less money now than ten years from now. Another reason that this is a good time to pass this bond is that the results of Ballot Measure 5 are going into effect at the same time as the levy. As it stands now, property tax rates will go down another $2.50 by next year; however, if taxpayers don't mind paying what they do now and can handle a 40 cent increase, then the school can be that much better.

Many other good reasons we exist for funding this construction now. For one, better facilities will be made available to everyone: staff members, students, and community members. The new gym will allow student athletes to have earlier practices and more time for homework. With only one gym in a K-12 school system, the junior high has to practice in the morning before school, starting at 6:30 A.M., meaning that both the girls and boys teams had to practice at the same time, with half of the court for the girls half for the boys. After school, the high school girls would practice from 3:30 to 5:30 P.M. The varsity boys would then start at 5:30 or 6:00 and go until 7:30. After that, the junior varsity boys would come in for an hour and a half. It's absurd to think that student athletes can make good use of their time with a schedule like that. If the bond were to pass, both the new gym and the present gym would be used for practices and athletes wouldn't have to wait so long to practice every day.

Another reason that the gym should be built is that it is no longer adequate. The bleachers are too close to the court and so there is no room to walk by without getting in the way during a game. The gym also poses a problem for the cheerleaders. As it is now, there is no room for them to cheer. They have to stand on one of the ends which, of course, is right in the way of people walking by. If a new gym were built, enough room would be provided surrounding the court that there wouldn't be any of the problems there are now.

Another advantage to the bond proposal is that it would provide more space in the school. The school has always been small, which is in some ways nice, but it needs to expand. The lack of space is a problem because everyone is crammed into one little hallway trying to make it around from class to class. As it is, there isn't enough room for the library to just be a library or the kitchen to just be a kitchen. Students can't even go to the library when they need to because Health, Media, and other classes are held there. The Satellite Learning classroom, which shares a space with the kitchen, usually has a difficult learning atmosphere each day people prepare food for the hot lunch program. Another problem area is the current science room and lab. Lab facilities are outdated and cannot be replaced for a variety of reasons related to the plumbing and electrical systems. Both science teachers have said publicly that the chemical storage room is inadequate and unsafe. The science curriculum is a core part of students' education and they deserve good facilities.

It is clear then, that ____ School needs significant improvements in which case the bond must be passed. As a community, education is an essential part of the future. In the past, ____ has relied in the timber industry for employment, but times are changing and the younger generations need to be better prepared to meet the challenges that arise. For example, they need to able to take part in a variety of activities and be able to achieve in many different areas. If the school is inadequate, how can the younger generations be provided with the education and training they need to be successful in the future?

Students in France are expected to be able "to construct an argument in order to demonstrate, convince, or persuade [someone to a point of view]."

Baccalauréat Professionnel: Enseignements généraux, p. 10.

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Work Sample & Commentary: *Dome*

1 Reading	**2 Writing**	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech Tools & Techniques	4 Learning & Self-mgmt Tools & Techniques	5 Tools & Techniques for Working With Others

Applied Learning

English Language Arts required by the task

Students were asked to choose a controversial issue facing the public, to state a judgment about the issue, and to argue for the judgment made.

Circumstances of performance

✓	timed assignment
	extended project
	opportunity for revision
✓	first draft
	revised draft
	teacher generated topic
✓	student generated topic
	embedded in class work
	research required

This work sample provides evidence for the quality of work expected for the following part of the English Language Arts standards:

Standard 2, Writing—produces a persuasive essay.

Writing

The student produces:

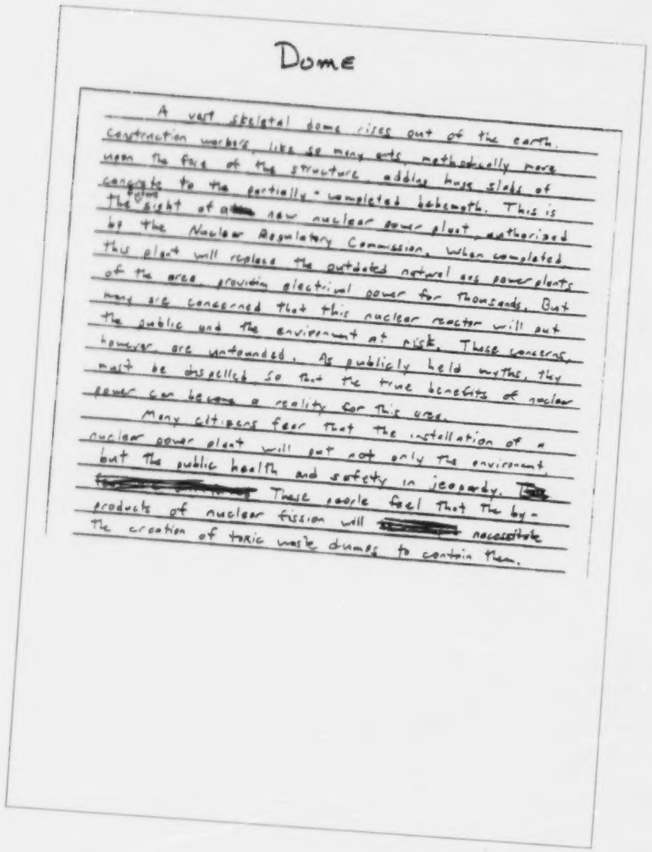
A persuasive essay, in which the writer:

- **engages the reader by establishing a context, creating a persona, and otherwise developing reader interest;**
- **develops a controlling idea that makes a clear and knowledgeable judgment;**
- **creates an organizing structure that is appropriate to the needs, values, and interests of a specified audience, and arranges details, reasons, examples, and anecdotes effectively and persuasively;**
- **includes appropriate information and arguments and excludes information and arguments that are irrelevant;**
- **anticipates and addresses reader concerns and counter arguments;**
- **supports arguments with detailed evidence, citing sources of information as appropriate;**
- **uses a range of strategies to elaborate and persuade, such as definitions, descriptions, illustrations, examples from evidence, and anecdotes.**

This work provides evidence that the student:

- engages the reader by establishing a context, i.e., the confusion over nuclear power, and creating a clear persona through the use of strong, persuasive language: "the outdated natural gas power plants"; "publicly held myths"; "true benefits of nuclear power";
- develops a controlling idea with clear judgments: "These concerns, however, are unfounded"; "These fears are uninformed"; "The benefits of such a plant…are clearly visible to all";
- organizes the structure of the argument logically by laying out possible concerns and issues, e.g., public and environmental risks; by dividing the concerns and issues into more specific parts, e.g., public risk of toxic waste, radiation, nuclear accidents and environmental risks to wildlife; by addressing each potential concern; and by discussing the benefits of nuclear power;
- provides informative arguments that deal with reader concerns, e.g., refers to the positive aspect of increased knowledge from historical nuclear accidents familiar to readers, such as Chernobyl and Three Mile Island; describes plant construction; counters claims regarding radioactive risk with claims about the level of radiation from the sun.

Errors in this first draft, e.g., "sight" for "site," "accomodated" for "accommodated" and "repayed" for "repaid," may be attributed to the nature of the task, which was given in a timed writing situation. The writing was completed in forty-five minutes with no opportunities for review and revision. The spelling and grammatical errors in this work sample do not detract from the overall quality of the work.



Dome

A vast skeletal dome rises out of the earth. Construction workers, like so many ants, methodically move upon the face of the structure, adding huge slabs of concrete to the partially completed behemoth. This is the sight of a new nuclear power plant, authorized by the Nuclear Regulatory Commission. When completed, this plant will replace the outdated natural gas power plants of the area, providing electrical power for thousands. But many are concerned that this nuclear reactor will put the public and the environment at risk. These concerns, however, are unfounded. As publicly held myths, they must be dispelled so that the true benefits of nuclear power can become a reality for this area.

Many citizens fear that the installation of a nuclear power plant will put not only the environment, but the public health and safety in jeopardy. [redacted] These people feel that the by-products of nuclear fission will [redacted] necessitate the creation of toxic waste dumps to contain them.

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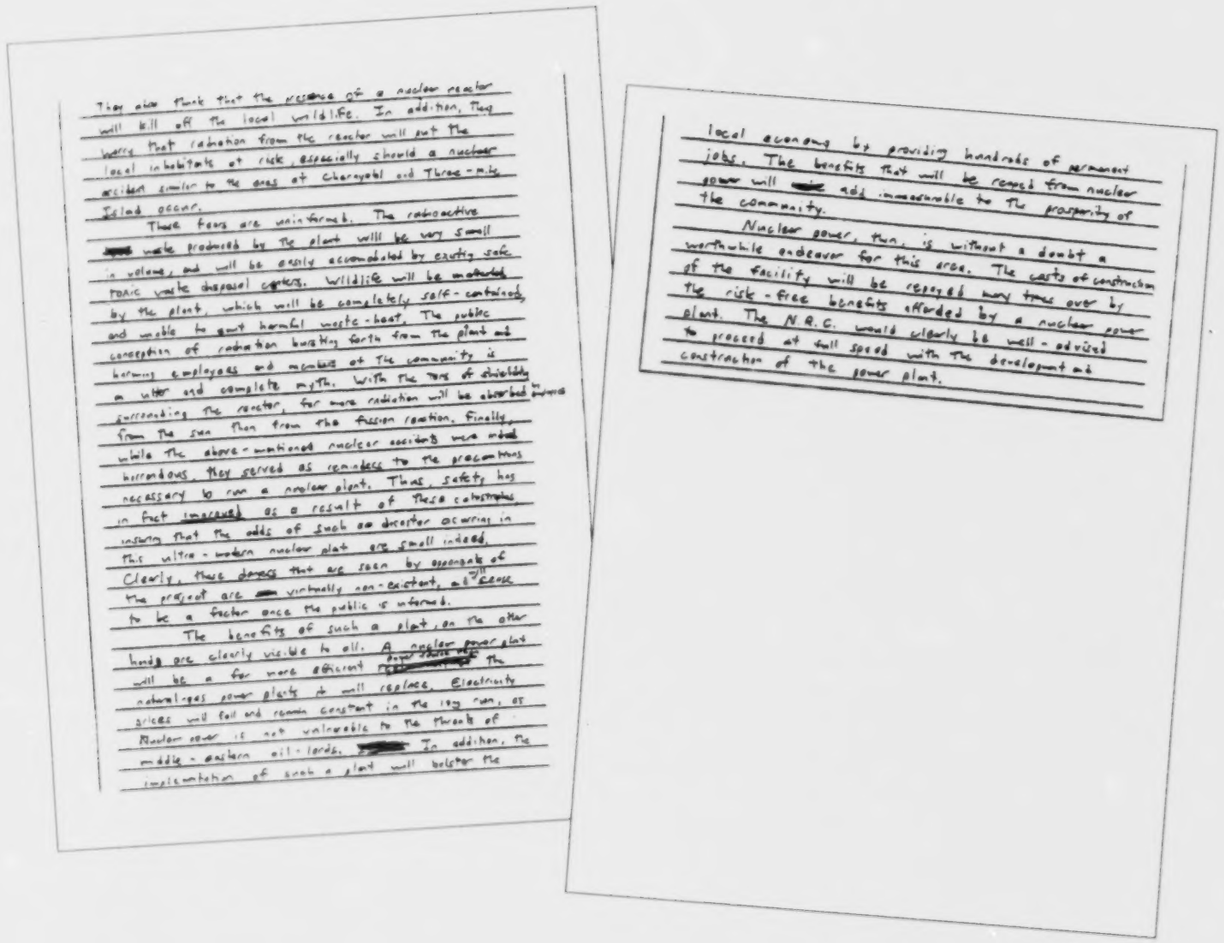

They also think that the presence of a nuclear reactor will kill off the local wildlife. In addition, they worry that radiation from the reactor will put the local inhabitants at risk, especially should a nuclear accident similar to the ones at Chernyobl and Three-mile Island occur.

These fears are misformed. The radioactive ~~waste~~ waste produced by the plant will be very small in volume, and will be easily accomodated by existing safe toxic waste disposal systems. Wildlife will be unharmed by the plant, which will be completely self-contained and unable to emit harmful waste-heat. The public conception of radiation bursting forth from the plant and harming employees and members of the community is an utter and complete myth. With the use of shielding surrounding the reactor, far more radiation will be absorbed from the sun than from the fission reaction. Finally, while the above-mentioned nuclear accidents were indeed horrendous, they served as ~~remedies~~ to the precautions necessary to run a nuclear plant. Thus, safety has in fact increased as a result of these catastrophes, insuring that the odds of such an disaster occurring in this ultra-modern nuclear plant are small indeed. Clearly, those dangers that are seen by opponents of the project are ~~—~~ virtually non-existent, although ~~to~~ to be a factor once the public is informed.

The benefits of such a plant, on the other hand, are clearly visible to all. A nuclear power plant will be a far more efficient ~~replacement~~ power source than the natural-gas power plants it will replace. Electricity prices will fall and remain constant in the long run, as Nuclear power is not vulnerable to the threats of middle-eastern oil-lords. ~~—~~ In addition, the implementation of such a plant will bolster the local economy by providing hundreds of permanent jobs. The benefits that will be reaped from nuclear power will ~~—~~ add immeasurable to the prosperity of the community.

Nuclear power, then, is without a doubt a worthwhile endeavor for this area. The costs of construction of the facility will be repayed many times over by the risk-free benefits afforded by a nuclear power plant. The N.R.C. would clearly be well-advised to proceed at full speed with the development and construction of the power plant.

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Students in Ontario, Canada are expected to "be able to analyze how technology affects the world of work; understand the concept of "sustainable development"; be able to analyze information to form opinions and plan for the future."

The Common Curriculum, Grades 1–9, p. 72.

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Work Sample & Commentary: *A Different World*

1 Reading	**2 Writing**	3 Speaking, Listening & Viewing	**4 Conventions, Grammar & Usage**	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech Tools & Techniques	4 Learning & Self-mgmt Tools & Techniques	5 Tools & Techniques for Working With Others

Applied Learning

English Language Arts required by the task

Students were asked to narrate an ordinary occasion or experience, choosing effective details and images, and to move beyond the narration to reflect either personally or generally about the occasion or experience.

Circumstances of performance

✓	timed assignment
	extended project
	opportunity for revision
✓	first draft
	revised draft
	teacher generated topic
✓	student generated topic
	embedded in class work
	research required

This work sample provides evidence for the quality of work expected for the following parts of the English Language Arts standards:

Standard 2, Writing—produces a reflective essay;
Standard 4, Conventions, Grammar, and Usage of the English Language—uses appropriate conventions.

Writing

The student produces:

A reflective essay, in which the writer:

- **engages the reader by establishing a context, creating a persona, and otherwise developing reader interest;**
- **analyzes a condition or situation of significance;**
- **develops a commonplace, concrete occasion as the basis for the reflection, e.g., personal observation or experience;**
- **creates an organizing structure appropriate to purpose and audience;**
- **uses a variety of writing strategies, such as concrete details, comparing and contrasting, naming, describing, creating a scenario.**

This work provides evidence that the student:

- engages the reader by beginning with a metaphor involving "ancient navigators" who "steer their ships by the stars," then leading from a generalized "sea of life" to a personalized "grandmother" who gives her grandchild values "that serve as stars in the sea of my life";
- develops a commonplace, concrete occasion as the basis of reflection, i.e., a family reunion with a grandmother about whom the writer has only heard;
- creates an organizing structure by narrating a single experience, moving in and out of that experience, and exploring its impact: "It [the trip and the meeting with the grandmother] symbolized another path to take or another star to steer my life by" and "my grandmother has passed down to me values and principles I will always live by"; in addition, the sample uses a central metaphor as a bridge to move from personal to general reflection: "The sea of life requires the study of some stars by which our direction… can be checked once in a while";
- effectively uses concrete language to describe details: "an old shack made out of bamboo sticks, chickens [that] flocked everywhere," and "flies that seemed to be attacking me."

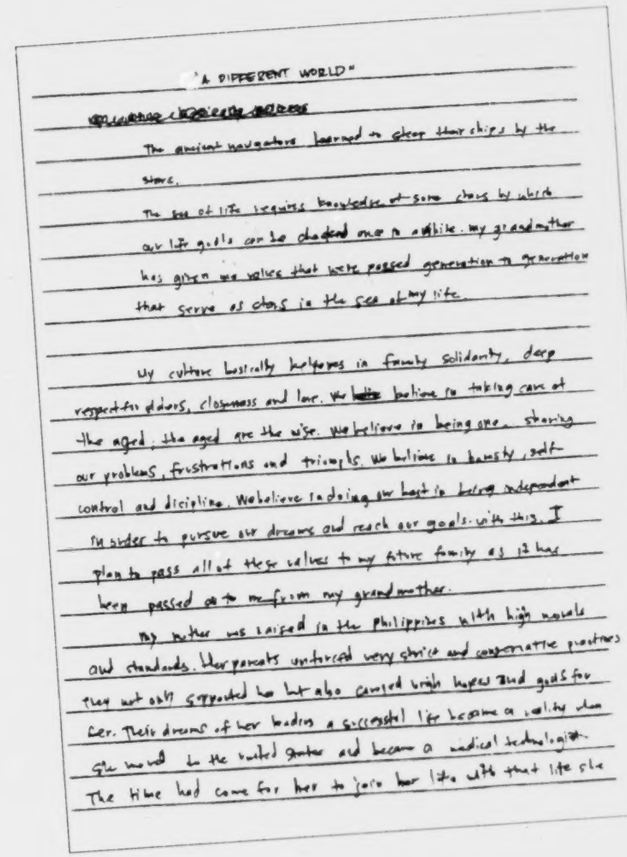
Conventions, Grammar, and Usage of the English Language

The student independently and habitually uses the appropriate conventions of the English language, including:

- **spelling;**
- **sentence construction;**
- **paragraph structure;**
- **punctuation;**
- **grammar;**
- **usage.**

This work provides evidence that the student:

- in almost error free writing, manages grammar, sentence construction, paragraph construction, usage, spelling, and punctuation.



"A DIFFERENT WORLD"

The ancient navigators learned to steer their ships by the stars.

The sea of life requires knowledge of some stars by which our life goals can be checked once in a while. My grandmother has given me values that were passed generation to generation that serve as stars in the sea of my life.

My culture basically harbors in family solidarity, deep respect for elders, closeness and love. We believe in taking care of the aged, the aged are the wise. We believe in being one, sharing our problems, frustrations and triumphs. We believe in having self-control and discipline. We believe in doing our best in being independent in order to pursue our dreams and reach our goals with this, I plan to pass all of these values to my future family as it has been passed on to me from my grandmother.

My mother was raised in the philippines with high moral and standards. Her parents instilled very strict and conservative practices that not only supported her but also carried with hopes and goals for her. Their dreams of her leading a successful life became a reality when she moved to the united states and became a medical technologist. The time had come for her to join her life with that life she

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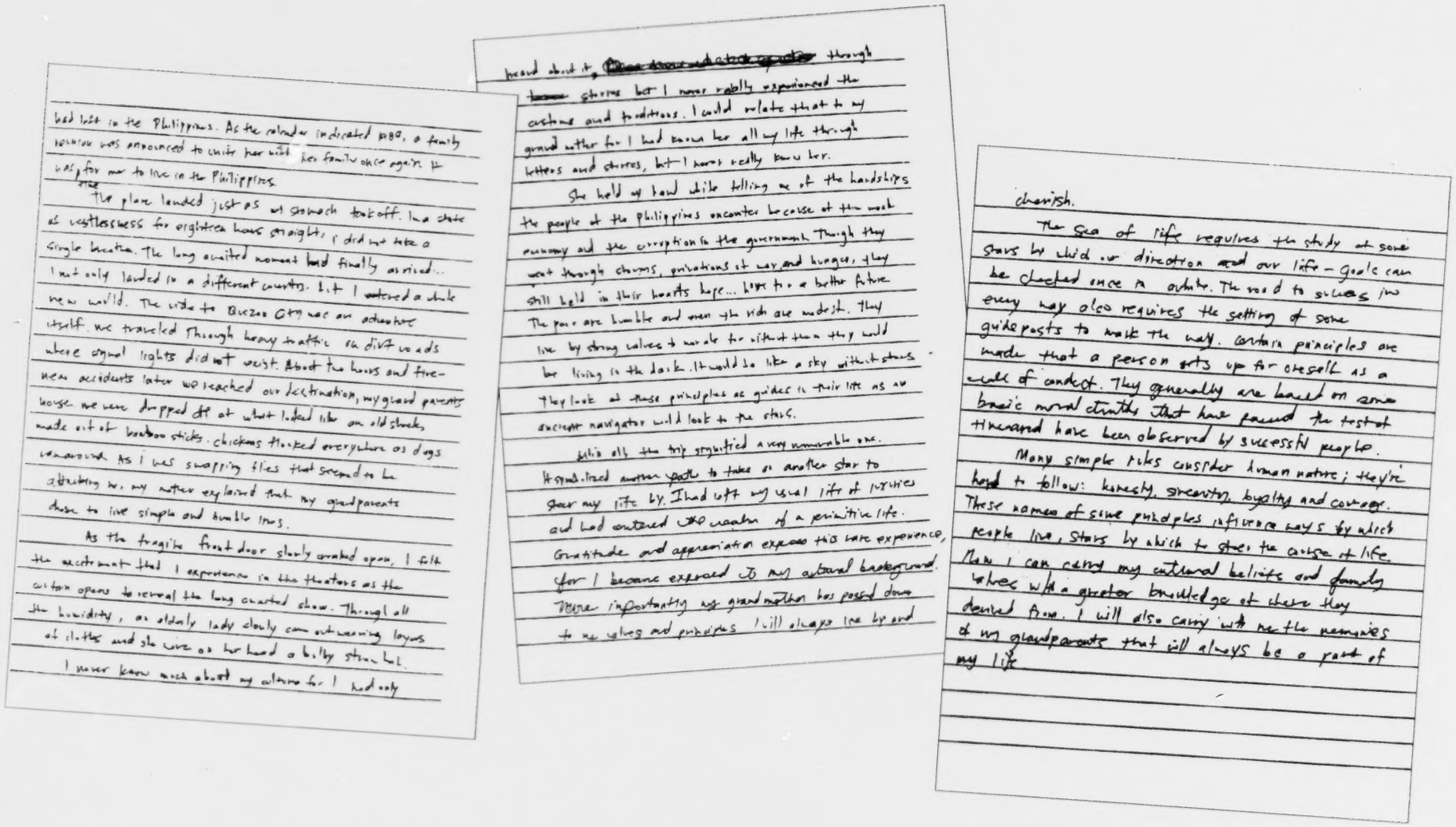

had left in the Philippines. As the calendar indicated 1980, a family reunion was announced to unite her with her family once again. It was for me to live in the Philippines.

The plane landed just as my stomach took off. In a state of restlessness for eighteen hours straight, I did not take a single breathe. The long awaited moment had finally arrived... I not only landed in a different country, but I entered a whole new world. The ride to Quezon City was an adventure itself. We traveled through heavy traffic on dirt roads where signal lights did not exist. About two hours and five near accidents later we reached our destination, my grandparents house. We were dropped off at what looked like an old shack, made out of bamboo sticks. chickens flocked everywhere as dogs ran around. As I was swatting flies that seemed to be attracted to me, my mother explained that my grandparents chose to live simple and humble lives.

As the fragile front door slowly creaked open, I felt the excitement that I experience in the theaters as the curtain opens to reveal the long awaited show. Through all the humidity, an elderly lady slowly came out wearing layers of clothes and she was as tan as a billy stone tile.

I never knew much about my culture for I had only

heard about it, ~~[illegible]~~ through stories but I never really experienced the customs and traditions. I could relate that to my grand mother for I had known her all my life through letters and stories, but I never really knew her.

She held my hand while telling me of the hardships the people of the Philippines encounter because of the weak economy and the corruption in the government. Though they went through storms, privations of war and hunger, they still held in their hearts hope... hope for a better future. The poor are humble and even the rich are modest. They live by strong values to guide them without them they would be living in the dark. It would be like a sky without stars. They look at these principles as guides to their life as an ancient navigator would look to the stars.

All of the trip signified a very memorable one. It stimulated another goal to take as another star to steer my life by. I had left my usual life of luxuries and had entered into vacation of a primitive life. Gratitude and appreciation exposed this rare experience, for I became exposed to my cultural background. More importantly my grandmother has passed down to me values and principles I will always live by and cherish.

The sea of life requires the study of some stars to guide our direction and our life - goals can be charted once in awhile. The road to success in every way also requires the setting of some guideposts to mark the way. Certain principles are made that a person sets up for oneself as a code of conduct. They generally are based on some basic moral truths that have passed the test of time and have been observed by successful people.

Many simple rules consider human nature; they're hard to follow: honesty, sincerity, loyalty and courage. These names of some principles influence ways by which people live, stars by which to steer the course of life. Now I can carry my cultural beliefs and family values with a greater knowledge of where they derived from. I will also carry with me the memories of my grandparents that will always be a part of my life.

Students entering lycée in France in 1994 were asked to write on the following subject: "Do you think that your entry into lycée will provide you with new freedoms in your life at home and in school? Your response to this question should include three arguments, each illustrated with a precise example."

Évaluation à l'entrée en seconde générale et technologique: Français, Septembre 1994, Ministère de l'Education Nationale.

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Work Sample & Commentary: *Grandma*

1 Reading	2 Writing	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	**5 Literature**	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech Tools & Techniques	4 Learning & Self-mgmt Tools & Techniques	5 Tools & Techniques for Working With Others

Applied Learning

English Language Arts required by the task

Students were asked to write a poem about a subject that meant a great deal to them.

Circumstances of performance

	timed assignment
✓	extended project
✓	opportunity for revision
	first draft
✓	revised draft
	teacher generated topic
✓	student generated topic
	embedded in class work
	research required

This work sample provides evidence for the quality of work expected for the following part of the English Language Arts standards:

Standard 5, Literature—demonstrates proficiency in at least one literary genre.

Literature

The student demonstrates proficiency in at least one literary genre.

This poem provides evidence that the student:

- clearly demonstrates an understanding of a variety of poetic devices, e.g., the use of repetitions to reinforce the idea that youth fears old age ("I'm scared");
- effectively contrasts visual images of Grandma as "the matriarch of our clans,/a successful woman,/an educated housewife…" with an old woman who wears a torn sweater and "Wanders around, arms wrapped together/with wisdom weighing heavy on her/back";
- employs concrete images that suggest what the piece is trying to say rather than state it directly: "her steady,/slow, crumpled pace," "with wisdom weighing heavy on her/back," "A brain like a faded book,/…with the last chapter/faded away";
- moves from not understanding the changes that aging creates in a much loved and admired grandmother (a somewhat removed and generalized view) to being frightened of those changes because they may come to all who age (a personal view);
- capably uses metaphor and simile (see the third bullet point above); alliteration: "Wanders around, arms wrapped together/with wisdom weighing…," "states straight," "familiar face," "Sitting on the swing"; as well as strong image-producing verbs and verb forms: "mumbles," "crumpled," "faded";
- uses white space to set off the parts of the poem.

SPECIAL FOLKS

Grandma

Grandma,
the matriarch of our clans,
a successful woman,
an educated housewife,
a survivor of the
French Revolution

What Happened? I did not understand.

"Tick Tick Tong Tong "
Alarm went off at 5 am.
Grandma holds tight a rosary,
sits on her bed, mumbles the prayer,
"Please, God, bless and
protect my children,"
in the usual black pants,
with old torn sweater.

Carefully reaches for each step,
concentrates on her sturdy,
slow, crumpled pace.

Loves to work,
tried to be helpful,
"Grandma, you don't have to do my
laundry."
Withers in a rejected, crying voice,
"You think I am dirty,
you don't like my work."

Carefully pulls the weeds,
waters the green grass,
plants flowers in the back yard.

What is happening? I don't understand
I'm scared

Wanders around, arms wrapped together
with wisdom weighing heavy on her
back,
squishing
with black slippers.

Puts one hand on forehead to
cover the bright rays of the light,
stares straight into the familiar face
wrinkles her forehead, curiously asks
"Who are you?"

I'm scared. I'm scared

Sitting on the swing,
with the Bible,
a pair of eyeglasses in hand,
concentrates hard on reading
Can see blue veins running,
wrinkles on her forehead.
Tells stories of wars,
the Revolution.

How can an intellectual
woman become a kid?
So ridiculous, so strange

A brain like a faded book,
so many interesting stories,
experiences of life,
with the last chapter
faded away.

I'm scared, of losing
the inspiration of life,
but I wonder
Will I be like this when I am old?
Will I?

An extended project, here, is one that has occurred over a sustained period of time, generally at least one week, and often longer.

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Work Sample & Commentary: *All Quiet on the Western Front*

1 Reading	2 Writing	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech Tools & Techniques	4 Learning & Self-mgmt Tools & Techniques	5 Tools & Techniques for Working With Others

Applied Learning

An extended project, here, is one that has occurred over a sustained period of time, generally at least one week, and often longer.

English Language Arts required by the task

Students were asked to write a literary analysis of a novel.

Circumstances of performance

	timed assignment
✓	extended project
✓	opportunity for revision
	first draft
✓	revised draft
	teacher generated topic
✓	student generated topic
	embedded in class work
	research required

This work sample provides evidence for the quality of work expected for the following parts of the English Language Arts standards:

Standard 2, Writing—produces a response to literature;

Standard 4, Conventions, Grammar, and Usage of the English Language—uses appropriate conventions;

Standard 5, Literature—responds to fiction.

Writing

The student produces:

A response to literature, in which the writer:

- **engages the reader through establishing a context, creating a persona, and otherwise developing reader interest;**
- **advances a judgment that is interpretive, analytic, evaluative, or reflective;**
- **supports a judgment through references to the text, references to other works, authors, or non-print media, or references to personal knowledge;**
- **demonstrates understanding of the literary work through suggesting an interpretation;**
- **anticipates and answers a reader's questions;**
- **recognizes possible ambiguities, nuances, and complexities.**

This work provides evidence that the student:

- engages the reader by establishing a context, i.e., begins with a block quotation that forecasts both the essay's theme, the loss of a generation, and the interpretive judgments to follow;
- creates an initial persona that is somewhat remote, rather like a newspaper reporter, e.g., uses passive verbs such as "was…portrayed" and "was illustrated"; but breaks with the initial persona in the last paragraph, e.g., refers to "our fathers" and "our Grandfathers," which draws the reader closer to the writer and the claims made;
- advances an interpretive judgment by saying that symbolism "portrayed the message" of the novel, which is seen as the loss of a generation;
- supports the judgment through references to the text, including quotations and paraphrases;
- demonstrates understanding of the literary work by analyzing the author's craft, considering how Remarque uses symbolism on at least three occasions to reinforce the theme of loss and destruction caused by war, e.g., Paul's leave, the two coffins at the destroyed school, the "Iron Youth" analogy;
- makes connections to broad issues by considering in the last paragraph how "our fathers" and "our Grandfathers" might have felt about the wars they fought.

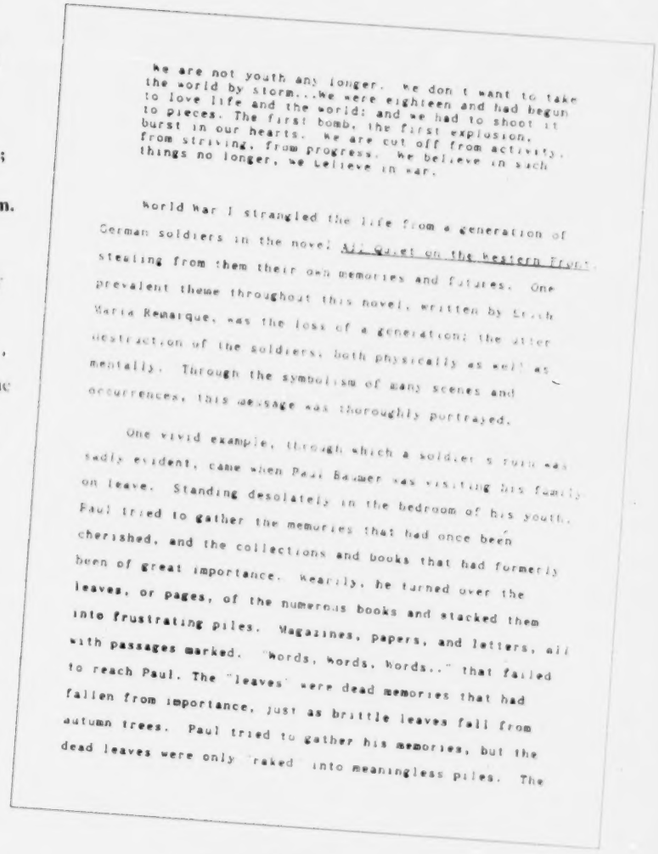
Literature

The student responds to fiction, non-fiction, poetry, and drama using interpretive, critical, and evaluative processes; that is, the student does one or more of the following in oral and written presentations:

- **makes inferences and draws conclusions about content, events, characters, setting, theme, and style;**
- **interprets the effect of literary devices, such as figurative language, allusion, diction, dialogue, description, symbolism;**
- **evaluates the impact of authors' decisions regarding word choice, style, content, and literary elements;**
- **analyzes the characteristics of literary forms and genres;**
- **evaluates literary merit;**
- **explains the effect of point of view;**
- **makes thematic connections among literary texts, public discourse, and media;**
- **interprets ambiguities, subtleties, contradictions, ironies, and nuances;**
- **demonstrates how literary works reflect the period which shaped them.**

This work provides evidence that the student:

- makes inferences about the message of a literary work, e.g., "World War I strangled the life from a generation of German soldiers";
- interprets a variety of images Remarque uses in the story, e.g., the burned out schoolhouse indicates "that what all the soldiers were taught, all they had ever believed in and cherished, was meaningless"; the coffins leaning up against the schoolhouse "embodied the fact that the boys… were men who had been hardened by the death and destruction of combat"; the schoolhouse and the coffins together suggest that "because they [the soldiers] had been stripped of their memories, they were already dead; and the coffins were already waiting";
- interprets an interesting ambiguity by exploring the implications of using the term "Iron Youth" for young German soldiers, e.g., "Just as iron rusts, the soldiers lives 'rusted.'"



We are not youth any longer. We don't want to take the world by storm...We were eighteen and had begun to love life and the world: and we had to shoot it to pieces. The first bomb, the first explosion, burst in our hearts. We are cut off from activity, from striving, from progress. We believe in such things no longer, we believe in war.

World War I strangled the life from a generation of German soldiers in the novel All Quiet on the Western Front stealing from them their own memories and futures. One prevalent theme throughout this novel, written by Erich Maria Remarque, was the loss of a generation; the utter destruction of the soldiers, both physically as well as mentally. Through the symbolism of many scenes and occurrences, this message was thoroughly portrayed.

One vivid example, through which a soldier's ruin was sadly evident, came when Paul Baumer was visiting his family on leave. Standing desolately in the bedroom of his youth, Paul tried to gather the memories that had once been cherished, and the collections and books that had formerly been of great importance. Wearily, he turned over the leaves, or pages, of the numerous books and stacked them into frustrating piles. Magazines, papers, and letters, all with passages marked. "Words, words, words..." that failed to reach Paul. The "leaves" were dead memories that had fallen from importance, just as brittle leaves fall from autumn trees. Paul tried to gather his memories, but the dead leaves were only raked into meaningless piles. The

Conventions, Grammar, and Usage of the English Language

The student independently and habitually uses the appropriate conventions of the English language, including:

- **spelling;**
- **sentence construction;**
- **paragraph structure;**
- **punctuation;**
- **grammar;**
- **usage.**

This work provides evidence that the student:

- in almost error free writing and with almost perfect punctuation, manages a variety of sentence constructions, e.g., in paragraph three.

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In Japan, students are expected "to read excellent writing and think about the conditions of good writing, and to make use of them in one's own writing."

Course of Study for Upper Secondary Schools in Japan, p. 15

young man sadly realized that he had nothing to cling to except the fact that he was a soldier. The War caused the mental destruction of the poor soldiers by stealing their memories and making everything seem insignificant.

Another scene in which this same message was illustrated described a ruined school-house. "...On the way we pass a shelled school-house. Stacked up against its longer side is a high double wall of yellow, unpolished, brand-new coffins..." This scene was also symbolic of the destruction of the boys' mentality. The school-house represented more than its demolished bricks and broken walls; the soldiers were shelled as well as the actual building. The broken school-house revealed that what all the soldiers were taught, all they had ever believed in and cherished, was meaningless. The symbolic coffins embodied the fact that the boys were no longer childhood school-mates, but men who had been hardened by the death and destruction of combat. Some soldiers remarked to themselves, "The coffins are really for us. Emotionally, because they had been stripped of their memories, the soldiers were dead; and the coffins were already waiting.

In the midst of war and death, those coffins would be filled. Though the soldiers were already dead in an emotional aspect, the war physically caused their annihilation as well. "He fell..on a day that was so quiet and still on the whole front, that the army report confined itself to the single sentence: All quiet on the Western Front." This specific scene seems to include the death of every soldier killed in the war, because all was quiet, and the specific soldier who fell was not clearly defined. "He," therefore, might indicate the universal death of every soldier. Because the war had taken their memories and their futures, the faces of the dead soldiers had shown an expression of calm, "as though almost glad the end had come."

The German soldiers of World War I were dubbed the "Iron Youth." This statement, made by the school master Kantorek, was very much symbolic of the soldiers' devastation. True, iron is a strong metal, and the soldiers were strong men. However, the misconceptions of war failed to explain that iron can be easily shaped and is used to bind and restrain, just as the war would easily shape the lives of the boys, refusing to let go. When the thousands of Kantoreks made this analogy, did they realize that Iron is a metal that is known to rust easily? Just as iron rusts, the soldiers lives "rusted." Shaped by war, they emotionally and physically died. "Iron Youth! Youth! We are none of us more than twenty years old. But young? Youth? That is long ago. We are old folk."

In conclusion, the message that the young soldiers were emotionally as well as physically killed as a result of the horrifying combat of World War I, was shown through many examples of symbolism throughout this novel. The "Iron Youth" rusted and died. Many soldiers felt they had become "...insensible dead men, who through some trick, some dreadful magic, [were] still able to run and kill." The shocking realization that our fathers might have felt this way in Vietnam, and our Grandfathers in World War II, seems an almost unbelievable connection. War sweeps away youth and life, destroying a soldier mentally and physically, leaving only a "wasteland" behind.

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Work Sample & Commentary: *Dialectical Journal: The Scarlet Letter*

1 Reading	2 Writing	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech. Tools & Techniques	4 Learning & Self-mgmt. Tools & Techniques	5 Tools & Techniques for Working With Others

Applied Learning

An extended project, here, is one that has occurred over a sustained period of time, generally at least one week, and often longer.

English Language Arts required by the task

Students were instructed to keep a dialectical journal of their reading. Regarding this particular journal the student says, "My dialectical journals are included [in my portfolio] because I feel that if it weren't for the journals that I did for *The Scarlet Letter,* I wouldn't have understood one sentence in the entire book."

Circumstances of performance

	timed assignment
✓	extended project
	opportunity for revision
✓	first draft
	revised draft
✓	teacher generated topic
	student generated topic
✓	embedded in class work
	research required

This work sample provides evidence for the quality of work expected for the following parts of the English Language Arts standards:

Standard 1, Reading—reads and comprehends material;

Standard 5, Literature—responds to fiction.

Reading

The student reads and comprehends material of the quality and complexity illustrated in the sample reading list equivalent to twenty-five books each year. The materials should include traditional and contemporary literature or the equivalent in magazines, newspapers, textbooks, and media, from at least three different literary genres and from at least five different writers. The student produces evidence of reading that:

- **demonstrates a thorough understanding of the text as a whole;**
- **identifies complexities presented in the text, i.e., ideas, information, levels of meaning;**
- **extracts salient information from the text;**
- **uses paraphrasing judiciously.**

This work provides evidence for the quality of work expected for this part of the reading standard. However, to say that the student has met this part of the reading standard, it would be necessary to include additional work of comparable quality.

This work provides evidence that the student:

- identifies complexities in the text by extending the analysis beyond the parameters of the text, e.g., applying knowledge of the text to present conditions and attitudes: "I understand this time period…we still do it today" [response 2] and "This is another example of how society…" [response 3];
- extracts salient information and makes connections, e.g., "This is another example of how society always puts the blame on the women for getting pregnant" [response 3].

Literature

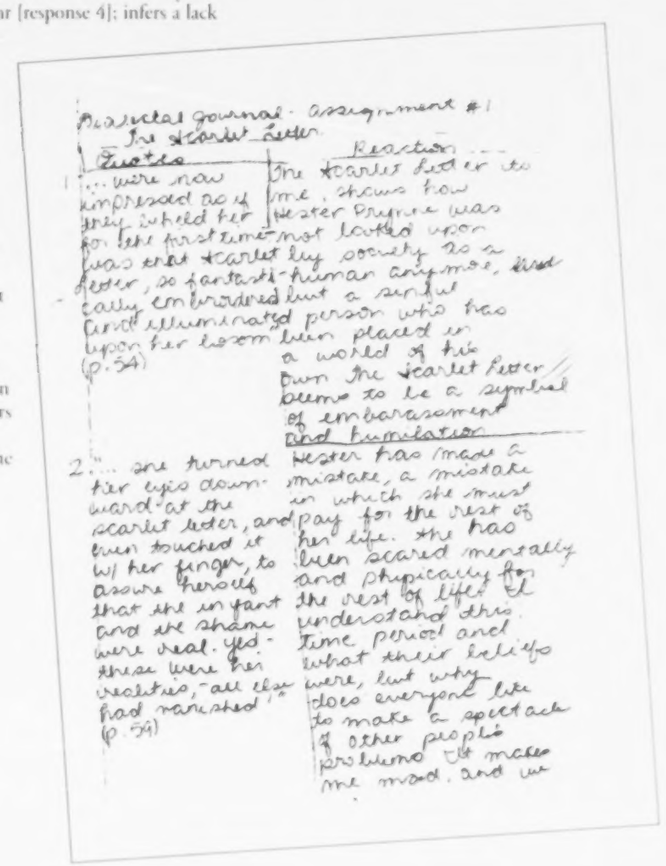
The student responds to fiction, non-fiction, poetry, and drama using interpretive, critical, and evaluative processes; that is, the student does one or more of the following in oral and written presentations:

- **makes inferences and draws conclusions about content, events, characters, setting, theme, and style;**
- **interprets the effect of literary devices, such as figurative language, allusion, diction, dialogue, description, symbolism;**
- **evaluates the impact of authors' decisions regarding word choice, style, content, and literary elements;**
- **analyzes the characteristics of literary forms and genres;**
- **evaluates literary merit;**
- **explains the effect of point of view;**
- **makes thematic connections among literary texts, public discourse, and media;**
- **interprets ambiguities, subtleties, contradictions, ironies, and nuances;**
- **demonstrates how literary works reflect the period which shaped them.**

This work provides evidence that the student:

- interprets symbolism, e.g., the scarlet letter is understood to represent embarrassment and humiliation [response 1];
- makes inferences about characters, e.g., sees Hester's action as an indication of mental scarring [response 2]; understands Hester's speech as indicative of her fear [response 4]; infers a lack of compassion in the public audience when Hester is brought to the market place [response 6].

A reading log is generally first draft writing done quickly for the sake of identifying the gist of what a student has read. The spelling and grammatical errors in this work include the misspelling of "scarred" in response two. These errors do not detract from the overall impression that the student has read and comprehended the work but would not be acceptable in polished writing.



Dialectical Journal - assignment #1
The Scarlet Letter

Quotes	Reaction
"...were now impressed as if they beheld her for the first time" (p. 54)	The scarlet letter to me, shows how Hester Prynne was not looked upon as that scarlet lay society as a whole, as fantastic-human animal, cruelly embroidered but a sinful and illuminated person who has been placed in a world of his own. The scarlet letter seems to be a symbol of embarrassment and humiliation.
2. "...she turned her eyes downward at the scarlet letter, and even touched it with her finger, to assure herself that the infant and the shame were real. Yes - these were realities, - all else had vanished." (p. 54)	Hester has made a mistake, a mistake in which she must pay for the rest of her life. She has been scared mentally and physically for the rest of life. I understand this time period and what their beliefs were, but why does everyone like to make a spectacle of other people's problems. It makes me mad. and we

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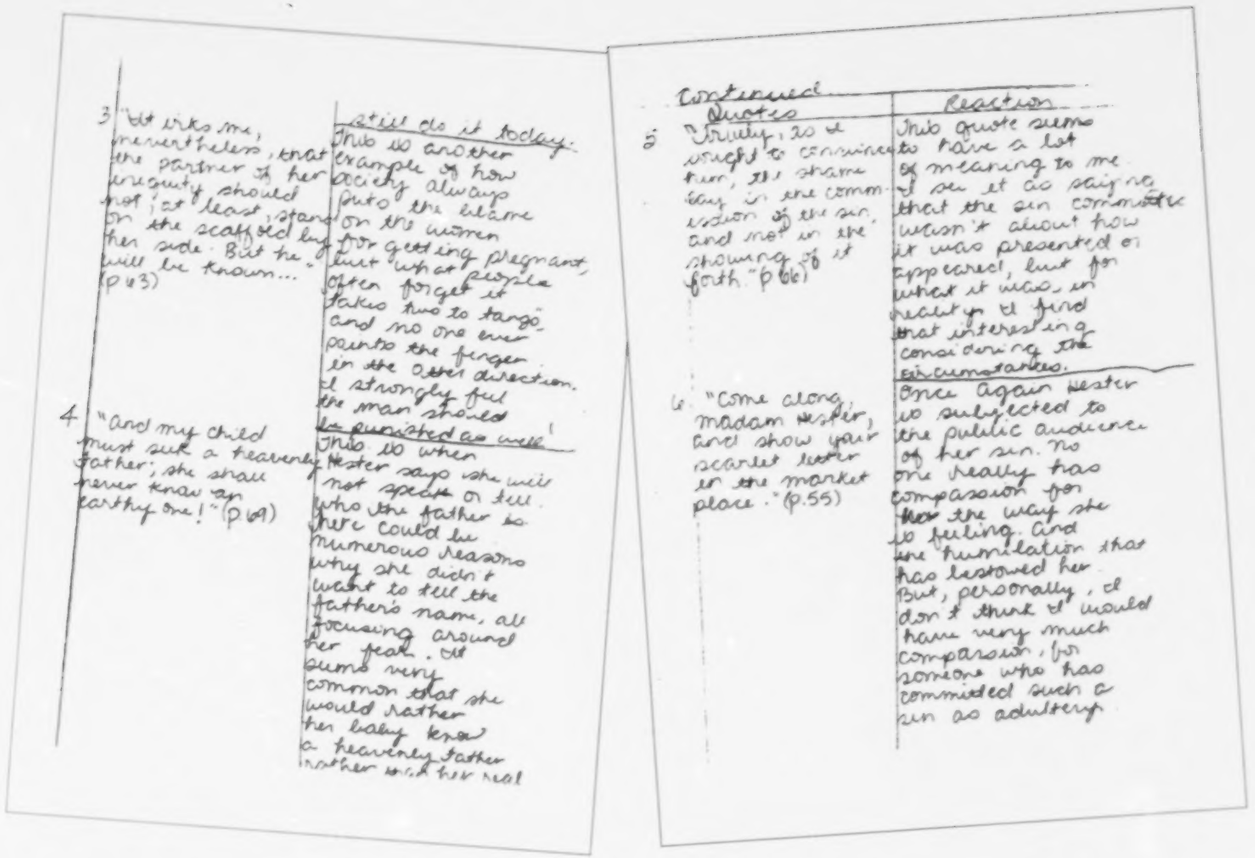

	Still do it today:
3 "It irks me, nevertheless, that the partner of her iniquity should not, at least, stand on the scaffold by her side. But the day will be known..." (p. 63)	This is another example of how society always puts the blame on the women for getting pregnant, but what people often forget is it takes two to tango, and no one ever points the finger in the other direction. I strongly feel the man should be punished as well!
4 "And my child must seek a heavenly father; she shall never know an earthly one!" (p. 69)	This is when Hester says she will not speak or tell who the father is. There could be numerous reasons why she didn't want to tell the father's name, all focusing around her fear. It seems very common that she would rather her baby know a heavenly father rather than her real

Continued Quotes	Reaction
5 "Truly, so it ought to comfort her, the shame dwelling in the commission of the sin, and not in the showing of it forth." (p. 66)	This quote seems to have a lot of meaning to me. I see it as saying that the sin committed wasn't about how it was presented or appeared, but for what it was, in reality. I find that interesting considering the circumstances.
6 "Come along, Madam Hester, and show your scarlet letter in the market place." (p. 55)	Once again Hester is subjected to the public audience of her sin. No one really has compassion for her the way she is feeling and the humiliation that has bestowed her. But, personally, I don't think it would have very much comparison, for someone who has committed such a sin as adultery

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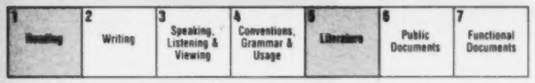
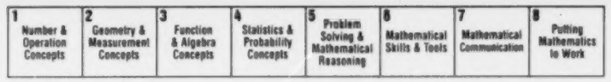
Japanese students are expected "to read about and appreciate characters, scenes, and sentiments described in accordance with expressions used."

Course of Study for Upper Secondary Schools in Japan, p. 16.

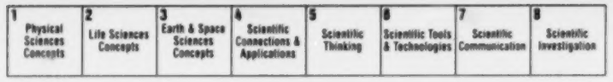
Work Sample & Commentary: *Dear...When I Told...*



English Language Arts


1 Number & Operation Concepts
2 Geometry & Measurement Concepts
3 Function & Algebra Concepts
4 Statistics & Probability Concepts
5 Problem Solving & Mathematical Reasoning
6 Mathematical Skills & Tools
7 Mathematical Communication
8 Putting Mathematics to Work

Mathematics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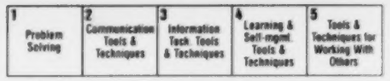
5 Scientific Thinking
6 Scientific Tools & Technologies
7 Scientific Communication
8 Scientific Investigation

Science


1 Problem Solving
2 Communication Tools & Techniques
3 Information Tech. Tools & Techniques
4 Learning & Self-mgmt. Tools & Techniques
5 Tools & Techniques for Working With Others

Applied Learning

An extended project, here, is one that has occurred over a sustained period of time, generally at least one week, and often longer.

English Language Arts required by the task

Students were asked to produce literary letters pertaining to a novel being read.

Circumstances of performance

	timed assignment
✓	extended project
	opportunity for revision
✓	first draft
	revised draft
	teacher generated topic
	student generated topic
✓	embedded in class work
	research required

This work sample provides evidence for the quality of work expected for the following parts of the English Language Arts standards:

Standard 1, Reading—reads and comprehends material; reads in depth;

Standard 5, Literature—responds to fiction.

Reading

The student reads and comprehends material of the quality and complexity illustrated in the sample reading list equivalent to twenty-five books each year. The materials should include traditional and contemporary literature or the equivalent in magazines, newspapers, textbooks, and media, from at least three different literary genres and from at least five different writers. The student produces evidence of reading that:

- **demonstrates a thorough understanding of the text as a whole;**
- **identifies complexities presented in the text, i.e., ideas, information, levels of meaning;**
- **extracts salient information from the text;**
- **uses paraphrasing judiciously.**

This work provides evidence for the quality of work expected for this part of the reading standard. However, to say that the student has met this part of the reading standard, it would be necessary to include additional work of comparable quality.

This work provides evidence that the student:

- identifies complexities presented in the text, e.g., "This was Conrad's greatest talent: using specific detail to suggest a general truth";
- uses paraphrasing judiciously, e.g., in repeating the final scene, the work quotes appropriate lines and paraphrases others in an attempt to make a point: "Perhaps this is the wrong insight, but I thought this scene was beautiful."

The student reads in depth at least four books (or book equivalents) about one issue or subject, or four books by a single writer, or four books in one genre, and produces evidence of reading that:

- **makes and supports warranted and responsible assertions about the texts;**
- **supports assertions with elaborated and convincing evidence;**
- **makes perceptive and well developed connections;**
- **evaluates writing strategies and elements of the author's craft.**

This work provides evidence for the quality of work expected for this part of the reading standard. However, to say that the student has met this part of the reading standard, it would be necessary to include additional work of comparable quality.

This work provides evidence that the student:

- makes assertions about the text, e.g., "This was Conrad's greatest talent: using specific detail to suggest a general truth";
- supports assertions with elaborated evidence by suggesting that "Throughout the book, when a character encounters something, first Conrad describes the sense of impressions which leads to a more detailed description of the thing which then concludes in an overall analysis of it" and then by supporting that assertion with textual evidence;
- evaluates elements of the author's craft, e.g., Conrad's use of "specific detail...descriptions and symbolism" was unfamiliar to the reader at first but in the end led to the declaration "I enjoyed reading *Heart of Darkness* because of the unusual style of writing."

Literature

The student responds to fiction, non-fiction, poetry, and drama using interpretive, critical, and evaluative processes; that is, the student does one or more of the following in oral and written presentations:

- **makes inferences and draws conclusions about content, events, characters, setting, theme, and style;**
- **interprets the effect of literary devices, such as figurative language, allusion, diction, dialogue, description, symbolism;**
- **evaluates the impact of authors' decisions regarding word choice, style, content, and literary elements;**
- **analyzes the characteristics of literary forms and genres;**
- **evaluates literary merit;**
- **explains the effect of point of view;**
- **makes thematic connections among literary texts, public discourse, and media;**
- **interprets ambiguities, subtleties, contradictions, ironies, and nuances;**
- **demonstrates how literary works reflect the period which shaped them.**

This work provides evidence that the student:

- makes inferences about characters by suggesting of Marlow "that somewhere on his journey he learned restraint from truth";
- evaluates the impact of the author's decisions regarding style, e.g., "the problem I was having with *Heart of Darkness* was Conrad's constant use of specific detail" and "This was Conrad's greatest talent: using specific detail to suggest a general truth";
- evaluates and reevaluates literary merit on an engaged level, i.e., the student moves from a position of "I...didn't particularly like it" to "I wanted to throw this book out the window" to "I enjoyed reading *Heart of Darkness*" and "I would look forward to reading other writing of his."

The genre of the literary letter is less formal than that of the critical book review, but it allows this student to respond to what is being read. The letter has not been through revision or careful editing. The spelling and grammatical errors in this work do not detract from the overall impression that the student has read and comprehended the work but would not be acceptable in polished writing.

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Dear

When I told my parents my English class would be reading Heart of Darkness, they were excited for me because they had both read it, and loved it. I was happy because usually, my parents recommend good books for me to read. I started Heart of Darkness and didn't particularly like it, or understand it. For the first assignment we had, I had to re-read the first twenty pages three times to better understand what was going on. I was sure reading this book and writing papers on it would bring me great difficulties.

As we went through it during class, and analyzed parts of it, I began to have a better grasp of it. I realized that the problem I was having with Heart of Darkness was Conrad's constant use of specific detail. Never before had I read a book that was so full of descriptions and symbolism. As many of there are different critiques of Joseph Conrad's Heart of Darkness, I believe many of them agree on one idea. The aim of Conrad's writing was to "make you hear, to make you feel, above all to make you see." This was Conrad's greatest talent; using specific detail to suggest a general truth. Throughout the book, when a character encounters something, first Conrad describes the sense of impressions which leads to more detailed description of the thing which then concludes in an overall analysis of it. An example of Conrad's use of specific detail is when Marlow encounters the Harlequin.

My favorite part of Heart of Darkness was at the end when Marlow is speaking with Kurtz's intended. She asks hem of her fiancee's last words. "Repeat them," she murmured in a heart- broken tone. "I want- I want-something- something-to-to-live with." She persisted when Marlow didn't answer. "His last words- to live with," she insisted. "Don't you understand I loved him-I loved him-I loved him!" Marlow proceeds to tell her that Kurtz's last words were of her.

Perhaps this is the wrong insight, but I thought this scene was beautiful. Marlow, throughout the entire book was supposed to be this incredibly moral person; it seems that somewhere on his journey he learned restraint from the truth. In this particular scene, Marlow lied to Kurtz's fiancee about Kurtz's last words before he died. Kurtz had really said "the horror, the horror," but Marlow, probably feeling compassionate, told her Kurtz had said her name. Marlow saw that this lady needed this illusion to survive Kurtz's death, so she could believe still that Kurtz was a wonderful, caring man down to his dying day.

Although at times I wanted to throw this book out the window because of all the frustration and confusion I had, I am glad now that I had the opportunity to read it. I enjoyed reading Heart of Darkness because of the unusual style of writing. I think Joseph Conrad extremely smart and clever to use so many different images and details and symbols to create this mysterious book. I would look forward to reading other writing of his.

Sincerely,

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Work Sample & Commentary: *Evidence of Reading*

1 **Reading**	2 Writing	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech Tools & Techniques	4 Learning & Self-mgmt Tools & Techniques	5 Tools & Techniques for Working With Others

Applied Learning

An extended project, here, is one that has occurred over a sustained period of time, generally at least one week, and often longer.

English Language Arts required by the task

Students were asked to keep a reading log throughout the year.

Circumstances of performance

	timed assignment
✓	extended project
	opportunity for revision
✓	first draft
	revised draft
	teacher generated topic
	student generated topic
✓	embedded in class work
	research required

This work sample provides evidence for the quality of work expected for the following part of the English Language Arts standards:

Standard 1, Reading—reads and comprehends material.

Reading

The student reads and comprehends material of the quality and complexity illustrated in the sample reading list equivalent to twenty-five books each year. The materials should include traditional and contemporary literature or the equivalent in magazines, newspapers, textbooks, and media, from at least three different literary genres and from at least five different writers. The student produces evidence of reading that:

- **demonstrates a thorough understanding of the text as a whole;**
- **identifies complexities presented in the text, i.e., ideas, information, levels of meaning;**
- **extracts salient information from the text;**
- **uses paraphrasing judiciously.**

This work provides evidence that the student:

- demonstrates an understanding of a series of texts from a variety of writers and genres;
- extracts salient information from each text, identifying the gist of what has been read;
- supplies a teacher certification that supports the assertion made at the beginning of the log: "The list below represents the books I have read this past year."

TEACHER CERTIFICATION

Quantity, Range, Depth in Reading

Student Name_____ Score: _____

You, as the classroom teacher, are in the best position to certify that a student is well-read and has met the standards for quantity, range, and depth in reading. Use the guidelines included in your portfolio materials and reprinted on the student entry slip to evaluate the evidence of reading that the student has provided (e.g., reading log, book reviews, bibliographies from research projects).

After examining the evidence, you may wish to hold a conference with the student if you have questions about whether he or she has met the standards or if, for example, a student has neglected to identify as evidence materials read outside your class or outside of school.

Use the space below for any comments you wish to make about the quantity, range, and depth of this student's reading.

has become an avid reader and she yearns for good literature. I have suggested several classic texts I read in college and she eagerly accepts any literary challenge. She has absorbed Shakespeare and her comprehension is beyond the majority of students I have taught. She connects themes from different texts and she can discuss creative comparisons and contrasts verbally and in writing. I can't think of any student who values learning more than this young lady. This portfolio portrays a year of hard work.

WRITE THE SCORE IN THE SPACE PROVIDED AT THE TOP OF THE PAGE.

I certify that the above information is correct.

Teacher Name

Teacher Signature

New Standards ELA Portfolio Field Trial DRAFT 7/95

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EVIDENCE OF READING

Annotated Bibliography of Books Read in the '94-'95 school year.

Les Livres

"Every time I open a book, I risk my life...Every work of imagination offers another view of life, an invitation to spend a few days inside someone else's emotions."

-Anatole Broyard

The list below represents the books I have read this past year...in our English curriculum and outside of class during my free time.

Cowboys Don't Cry, Marilyn Halvorson-A Young boy struggles to live a normal life with his father.

The Face on the Milk Carton, Caroline B. Cooney-Janie discovers the truth of the face on the milk carton...now she must live with the information she's uncovered.

Whatever Happened to Janie?, Caroline B. Cooney-Janie must choose between the family she truly loves, or the family she can't seem to get along with.

A Solitary Blue, Cynthia Voigt-A familiar story dealing with the pain of living life after your parents have gotten divorced.

The Gift, Peter Dickinson-Davey has the gift of seeing into other people's minds, but people don't always think good thoughts...not even the people you love.

The Moonstone, Wilkie Collins-When the curse finds you...you've found the Moonstone.

The Young Pitcher, Zane Grey-It's proof that hard work and sheer stubbornness will help you achieve any goal...no matter its size or shape.

Maine Ghosts and Legends, Thomas A. Verde-Don't turn around...the kiss of death may be creeping up behind you.

The Beans of Egypt, ME., Caroline Chute-The story of and "interesting" family living in the Maine woods.

The House of Mirth, Edith Wharton-A frail woman's struggle to keep pace with the high society life of New York City.

Taking Care of Terrific, Lois Lowry-The touching story of a young boy and his babysitter's caring relationship for the homeless of their town.

The Moon is Broken, Eleanor Craig-A dramatic, true story of a young woman's desperate fight against drugs and AIDS.

Fair Game, Erika Tamar-What seemed to be an innocent day after school, turned out to be the worst mistake the boys would ever make.

Ordinary People, Judith Guest-A story of a death...an attempted suicide and a family who must cope with the problems they have.

Ghost Girl, Torey Hayden-The shocking, true story of a traumatized young child's battle to emerge from her "shell".

The Scarlet Letter, Nathaniel Hawthorne-Hester was condemned for a sin which time would never erase...it had been etched into her heart forever.

A Day No Pigs Would Die, Robert Newton Peck-The hard lessons you learn in life will forever be with you...

Mrs. Dalloway, Virginia Woolf-The desire to regain childhood is often over-powering and Clarissa would ignore the realities of life to obtain it.

Dying for Chocolate, Diane Mott Davidson-A deceitful caterer's murder mystery that holds you in suspense until the last page.

Brave New World, Aldous Huxley-It's a whole new world where everything is being controlled to suit society's needs.

The Giver, Lois Lowry-Everyone is assigned roles in the community. Everything seemed so perfect...then Jonas began thinking...

Fahrenheit 451, Ray Bradbury-Books must have significance if the old lady was willing to die for them. Montag was determined to discover the truth...the only thing still in his way...Fahrenheit 451.

Much Ado About Nothing, William Shakespeare-A hilarious comedy with romance and deception galore.

Hamlet, William Shakespeare-Young Hamlet must avenge his father's death, but is murder the best way to solve the problem?

Loves Music, Loves to Dance, Mary Higgins Clark-The murderer is out there, waiting for the music to start...calling for him to kill again.

All Around the Town, Mary Higgins Clark-How may times will she have to relive that awful kidnapping over in her head? It may not be for much longer because her multiple personalities are slowly taking over.

While My Pretty One Sleeps, Mary Higgins Clark-That rapping on the window is not the wind...he's come for revenge...will you be ready?

A Stranger is Watching, Mary Higgins Clark-He'd abducted her because she'd ruined his life, now he was going to ruin hers. It was only a matter of time before the bomb went off and ended her life.

The Runner, Cynthia Voigt-Bullet ran because it made him feel good. He did it for himself and for nobody else. He would learn the hard way that someday, life will catch up with you.

The Jungle, Upton Sinclair-The repulsive and brutish story of the unsanitary conditions of the Chicago stockyards.

In England, students of this age should read "a range of drama, including a play by Shakespeare; a range of fiction, including one work published before 1900 by [a respected author] and one work published since 1900 by [a respected author]; a range of poetry, including poems by two significant poets whose works were published before 1900 and poems by three significant poets whose works were published since 1900; and a range of non-literary and non-fiction texts."

English in the National Curriculum, pp. 17–18.

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Samples of student work that help explain "how good is good enough" for these standards can be found immediately following these pages.

To see how these performance descriptions compare with the expectations for elementary school and middle school, turn to pages 102–109.

Several examples have sources cited. See References (p. 124) for details of the sources.

1. Number and Operation Concepts

The student:

- **uses the properties of addition, subtraction, multiplication, division, exponentiation, and root-extraction in forming and working with algebraic expressions;**
- **understands and uses unary operations, such as opposite, reciprocal, absolute value, raising to a fixed power, taking a root, and taking a logarithm;**
- **has facility with the mechanics of binary and unary operations as well as understanding of their typical meaning and uses in applications;**
- **understands and uses number systems, that is, natural, integer, rational, and real;**
- **represents numbers in decimal or fraction form and in scientific notation; and graphs numbers on the number line and in the coordinate plane;**
- **compares numbers of different magnitude using order relations, differences, ratios, proportions, percents, proportional change, and location on the number line;**
- **uses dimensionless numbers, such as proportions, percents, and multiplicative factors; and numbers with specific units of measure, including length, time, and rate units;**
- **recognizes and represents basic number patterns.**

Examples of performances that may demonstrate understanding include:

- ▲ figuring out how many pages one might use to write out all the numbers from 1 to 1,000,000 *(see Balanced Assessment Project);*
- ▲ showing that there must have been at least one misprint in a newspaper report on an election which read:
  - Yes votes 13,657 (42%)
  - No votes 186,491 (58%)

  and suggesting two different specific places a misprint might have occurred *(see Balanced Assessment Project);*
- ▲ solving the following problem: Given an infinite, four-column table with first row 1, 2, 3, 4, second row 5, 6, 7, 8, etc., show that if any number from the second column is added to any number from the third column, the result will be in the first column; generalize to other combinations of columns; and generalize to a seven-column table *(see New Standards Released Tasks);*
- ▲ figuring out, if 10% of U.S. citizens have a certain trait, and four out of five with the trait are men, what proportion of men have the trait and what proportion of women have the trait; explaining whether the answer depends on the proportion of U.S. citizens who are women and, if so, how *(see Balanced Assessment Project);*
- ▲ showing that the least common multiple of a and b, written [a, b], and the greatest common divisor of a and b, written (a, b), are related by [a, b] (a, b) = a b;
- ▲ showing how to enlarge a picture by a factor of 2 using repeated enlargements at a fixed setting on a photocopy machine that can only enlarge up to 155%; and doing the same for enlargements by a factor of 3, 4, and 5;
- ▲ giving a report on the basic uses of logarithmic scales in log-log and semi-log plots; in analog computing devices; and in physical phenomena, such as pH scales (acidity), decibel scales (sound intensity), and Richter scales (earthquake intensity).

2. Geometry and Measurement Concepts

The student:

- **works with many types of figures and their properties, including polygons and circles, cubes and pyramids, and cylinders, cones, and spheres;**
- **uses relationships between figures involving congruence and similarity; and characterizes such properties in terms of transformations;**
- **knows, uses, and derives formulas for area, surface area, and volume of many types of figures;**
- **uses the Pythagorean Theorem in many types of situations and knows how to prove the theorem;**
- **works with similar triangles and extends the ideas to include definitions and simple uses of the three basic trigonometric functions;**
- **analyzes figures in terms of the kinds of symmetries they have;**
- **studies geometric patterns, including sequences of growing shapes and characterizes the pattern in terms of properties of the nth stage;**
- **works with geometric measures of length, area, surface area, volume, and angle; and non-geometric measures of weight, monetary value, and time;**
- **uses quotient measures, such as speed and density, relating them to slope and "per unit" amounts; and uses product measures, such as person-days;**
- **understands the structure of standard measurement systems, both SI and customary, including derived units, unit conversions, and dimensional analysis;**
- **carries out proportional reasoning: in cases involving expansions and contractions, that is, in situations where sizes in the expanded or contracted figure are proportional to the corresponding sizes in the original figure; and in cases involving figures composed of many identical parts, that is, in situations where the size of the whole is proportional to the number of parts;**
- **solves problems involving scale and change of scale in maps and diagrams;**
- **represents geometric curves and graphs of functions in standard coordinate systems;**
- **analyzes geometric figures and proves things about them using deductive methods;**
- **models situations geometrically to formulate and solve problems.**

Examples of performances that may demonstrate understanding include:

- ▲ explaining which is a better fit, a round peg in a square hole or a square peg in a round hole, as well as trying a cube in a sphere vs. a sphere in a cube *(see Balanced Assessment Project);*
- ▲ solving the following problem: Suppose that you are on a cliff looking out to sea on a clear day. Show that the distance to the horizon in miles is about equal to 1.2 √h, where h is the height in feet of the cliff above sea level. Derive a similar expression in terms of meters and kilometers *(see Balanced Assessment Project);*
- ▲ determining if a cube can be dissected into congruent square-base pyramids or into triangle-base pyramids; in each case, showing how it can be done or why it cannot be done;
- ▲ exploring the relation between the length of a person's shadow (made by a streetlight) and the person's height and distance from the light; extending the analysis to include the rate of change of shadow length when the person is moving *(see Balanced Assessment Project);*
- ▲ designing a staircase that rises a total of 11 feet, given that the slope must be between .55 and .85, and that the rise plus the run on each step must be between 17 and 18 inches *(see Balanced Assessment Project; see also Applied Learning Standard 1);*
- ▲ solving the following problem: A model tower is made of small cubes of the same size. There are four types of cubes: corner, edge, face, and interior, having respectively 3, 2, 1, and 0 faces exposed. If a new tower of the same shape but three times as tall is to be built using the same sort of cubes, show how the numbers of each of the four types of cubes need to be increased. Generalize to a tower n times as tall as the original;
- ▲ solving the following problem: For a regular m-gon which "rolls" around a (stationary) regular n-gon of the same side length, figure out how many times the m-gon (1) rotates about the n-gon and (2) revolves on its axis before the starting position is touched again *(see Balanced Assessment Project).*

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3. Function and Algebra Concepts

The student:

- **models given situations with linear, exponential, or quadratic functions and interprets given functions in terms of situations;**
- **discovers, describes, generalizes, and uses basic types of functions; that is, linear, exponential, periodic, power, rational, squares and square roots, and cubes and cube roots;**
- **works with properties and mechanics of functions; that is, evaluation, inverses, slope, local maxima and minima;**
- **works with many kinds of rate relationships in constant rate situations;**
- **uses linear (arithmetic) sequences and exponential (geometric) sequences;**
- **defines and uses variables, parameters, constants, and unknowns in work with both functions and equations;**
- **solves equations both symbolically and graphically, especially linear, quadratic, and exponential equations; and knows the quadratic formula and its derivation;**
- **represents functional relationships in formulas, tables, and graphs, and translates among these;**
- **understands the basic algebraic structure of number systems;**
- **is familiar with 2 by 2 matrices, their arithmetic, and some of their uses, such as solving systems of equations and representing symmetries and transformations;**
- **uses equations to represent curves such as lines, circles, ellipses, parabolas, and hyperbolas;**
- **uses functions to represent patterns.**

Examples of performances that may demonstrate understanding include:

- using measurements from shopping carts which are nested together to find a formula for the number of carts that will fit in a given space and a formula for the amount of space needed for a given number of carts *(see Balanced Assessment Project);*
- expressing the diameter of a circle as a function of its area and sketching a graph;
- solving the following problem: Given a decreasing linear relationship between the selling price of a magazine and the number of people who will buy it and given a fixed cost per copy that goes to production, analyze the situation, showing that the profit (revenue minus costs) is a quadratic function of the number of copies sold, and find the selling price per copy that would maximize profits *(see Balanced Assessment Project; see also Applied Learning Standard 1);*
- figuring out which of two ways of rolling an 8.5" by 11" piece of paper into a cylinder gives the greater volume and whether there is a way to get even greater volume using a sheet of paper with the same area but different shape *(see Balanced Assessment Project);*
- solving the following problem: Given the formula for height of an object thrown upward with velocity v: $h(t) = h_0 + vt + (-\frac{1}{2})gt^2$, use quadratic functions and the quadratic formula to answer questions about the motion of projectiles and falling objects;
- discussing the relationship between solutions of equations of a particular type and inverses of functions of a particular type;
- solving the following problem: An earthquake generates two types of "waves" that travel through the Earth: "P-waves," which travel at 5.6 km/sec, and "S-waves," which travel at 3.4 km/sec. After an earthquake, the P-waves arrive at one recording station 15 seconds before the S-waves. Use functions, graphs, and equations to explain how far the recording station was from the epicenter of the earthquake. Show the flaw in this attempted solution: "The epicenter is 33 km away because the difference in velocities is 2.2 km/sec, and in 15 seconds that's 33 km";
- expressing the concentration of bleach as a function of the amount of water added to 3 liters of a 12% solution of bleach.

4. Statistics and Probability Concepts

The student:

- **collects, organizes, displays, and analyzes single-variable data using frequency distributions, histograms, and summary statistics;**
- **collects, organizes, displays, and analyzes two-variable data using scatter plots, estimated regression lines, and computer-generated regression lines and correlation coefficients;**
- **understands the role of assumptions and uncertainty in making inferences;**
- **critiques conclusions and the use of statistics in public documents;**
- **uses sampling techniques to draw inferences about large populations;**
- **explores questions of experimental design, use of control groups, and reliability;**
- **formulates hypotheses to answer a question and uses data to test hypotheses;**
- **uses theoretical probability models to arrive at probabilities for chance events;**
- **uses experimental measures of likelihood based on gathering of data to arrive at relative frequencies for chance events;**
- **uses simulations to estimate probabilities;**
- **sets up and works with appropriate sample spaces and applies the addition and multiplication principles appropriately;**
- **works with the normal distribution in some of its basic uses.**

Examples of performances that may demonstrate understanding include:

- showing how to make estimates of the size of a large population by capturing, marking, and returning individuals to the population, then sampling the population at a later time *(see Balanced Assessment Project);*
- making and supporting a prediction about who will win the completed tennis match, given the results of the initial games in a partially completed match among three players;
- solving the following problem: When two integers, each between 1 and 9 are selected at random, and then added, determine the possible sums and the probability of each; generalize to two integers between 1 and n; then, generalize to three integers between 1 and 9 *(see Balanced Assessment Project);*
- analyzing and interpreting prominent features of a scatter plot of several hundred data points, each giving a student's high school GPA and grade in freshman college calculus;
- explaining and illustrating the Law of Large Numbers;
- analyzing situations in which a test for a disease gives both false positives and false negatives; showing that in certain situations only a small proportion of positive test results may be from people who actually have the disease;
- exploring Simpson's Paradox: A may have a better record than B in each of two possible categories but B's overall record for those categories may be better than A's.

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To see how these performance descriptions compare with the expectations for elementary school and middle school, turn to pages 102–109.

Several examples have sources cited. See References (p. 124) for details of the sources.

5. Problem Solving and Mathematical Reasoning

See p. 42 for further clarification of this standard.

The student solves problems that make significant demands in one or more of these aspects of the solution process: problem formulation, problem implementation, and problem conclusion.

Problem formulation

The student participates in the formulation of problems; in particular, given the basic statement of a problem situation, the student:

- **fills out the formulation of a definite problem that is to be solved;**
- **extracts pertinent information from the situation as a basis for working on the problem;**
- **asks and answers a series of appropriate questions in pursuit of a solution and does so with minimal "scaffolding" in the form of detailed guiding questions.**

Problem implementation

The student makes the basic choices involved in planning and carrying out a solution; in particular, the student:

- **chooses and employs effective problem solving strategies in dealing with non-routine and multi-step problems;**
- **selects appropriate mathematical concepts and techniques from different areas of mathematics and applies them to the solution of the problem;**
- **applies mathematical concepts to new situations within mathematics and uses mathematics to model real world situations involving basic applications of mathematics in the physical sciences, the social sciences, and business.**

Problem conclusion

The student provides closure to the solution process through summary statements and general conclusions; in particular, the student:

- **concludes a solution process with a useful summary of results;**
- **evaluates the degree to which the results obtained represent a good response to the initial problem;**
- **formulates generalizations of the results obtained;**
- **carries out extensions of the given problem to related problems.**

Mathematical reasoning

The student not only makes observations and states results but also justifies or proves why the results hold in general; in particular, the student:

- **employs forms of mathematical reasoning and proof appropriate to the solution of the problem at hand, including deductive and inductive reasoning, making and testing conjectures, and using counterexamples and indirect proof;**
- **differentiates clearly between giving examples that support a conjecture and giving a proof of the conjecture.**

Examples of problem solving and mathematical reasoning include:

- ▲ discussing the mathematics underlying a sign along a road that says "7% Grade Next 3 Miles"; asking and then answering specific questions based on this situation *(see Balanced Assessment Project);*
- ▲ creating a mathematical model that will give an estimate for the volume of a bottle, given a front view and top view of the bottle drawn to scale; repeating for bottles of different shapes *(see New Standards Released Tasks);*
- ▲ showing that in a game for many players, in which each player rolls three dice and adds the three numbers, a sum of 3 has the same probability as a sum of 18; showing how to assign scores to each possible sum so that sums with the same probability get the same score, sums with twice the probability get half the score, and so on;
- ▲ investigating different ways of running a wire from the floor at one corner of a room to the ceiling at the opposite corner; finding the shortest wire under the following restrictions: (1) you can only run the wire along the edges of walls; (2) you can also run the wire across the face of a wall; (3) you can even run the wire through the air *(see Balanced Assessment Project);*
- ▲ exploring rectangular spaces enclosed by line segments laid out on a square lattice of dots; showing that the numbers of line segments, dots, and spaces enclosed are related by the formula L + 1 = D + S by reasoning as follows: the formula holds for the simplest arrangement of line segments and dots, and it is not changed through any of the possible ways of adding to an arrangement *(see Balanced Assessment Project)*

6. Mathematical Skills and Tools

The student:

- **computes accurately using arithmetic and algebraic operations on whole and rational numbers, using both pencil and paper and technology;**
- **makes reasonable estimates in appropriate units of quantities met in applications;**
- **evaluates and analyzes functions of many kinds, using both pencil and paper and technology;**
- **uses basic geometric terminology accurately and deduces information about basic geometric figures in solving problems;**
- **makes and uses rough sketches, schematic diagrams, or precise scale diagrams to enhance a solution;**
- **plots points on the number line, in the plane, and in space;**
- **creates and interprets graphs of many kinds, such as circle graphs, function graphs, scatter plots, regression lines, and histograms;**
- **sets up and solves equations symbolically (when possible) and graphically;**
- **uses technology to create graphs or spreadsheets that contribute to the understanding of a problem;**
- **knows how to write a simple computer program to carry out computations to be repeated many times;**
- **knows standard methods to solve basic problems and uses these methods in approaching more complex problems;**
- **carries out numerical calculations and symbol manipulations effectively, using mental computations, pencil and paper, or technological aids, as appropriate.**

Examples of mathematical skills and tools include:

- ▲ finding a formula for computing F from C, given that Celsius temperature C can be computed from the Fahrenheit temperature F by the formula C = (5/9)(F–32);
- ▲ figuring out the smallest and largest values of a certain number which rounded to one decimal place is 2.6 and rounded to two decimal places is 2.65; and illustrating on a number line;
- ▲ writing the general equation for a straight line that uses as parameters the x-intercept A and the y-intercept B;
- ▲ solving the following problem: Given three cities on a map, find a place that is the same distance from all of them; determine if there is always such a place and if there are ever many such places *(see Balanced Assessment Project);*
- ▲ calibrating and checking a bicycle odometer; showing how to take data about a trip collected with an incorrectly set odometer and convert it to accurate data *(see Balanced Assessment Project)*
- ▲ analyzing a standard reference guide such as the CRC handbook, identifying what information in it has been of use in your mathematics courses to date, and suggesting work that might make use of other information it contains.

7. Mathematical Communication

The student:

- **is familiar with basic mathematical vocabulary and terminology, standard notation and use of symbols, common conventions for graphing, and general features of effective mathematical communication styles;**
- **uses mathematical representations with appropriate accuracy, including numerical tables, formulas, functions, algebraic equations, charts, graphs, and diagrams;**
- **presents mathematical procedures and results clearly, systematically, succinctly, and correctly;**
- **communicates logical arguments clearly, showing why a result makes sense and why the reasoning is valid;**
- **describes and discusses mathematical ideas effectively both orally and in writing;**
- **explains mathematical concepts or ideas clearly to peers or others who may be having difficulty with them;**
- **reads mathematical texts and other writing about mathematics with understanding.**

Examples of mathematical communication include:

- ▲ discussing the implications for running tracks of various sizes and races of various lengths, given the fact that the starting lines for a race in outer lanes are farther forward than the starting lines in inner lanes; giving practical directions for laying out starting lines for particular races *(see Balanced Assessment Project);*
- ▲ reading a book written for the general public that discusses different fields of mathematics and reporting on one of these fields;
- ▲ designing a unit of instruction for middle school that does a good job of clarifying the role of proportionality, including (and showing) the relevance of concepts such as percent, ratio, similarity, and linear functions;
- ▲ writing a report on a ninth grade Japanese mathematics textbook (in English translation), comparing its features to those of comparable texts in this country;
- ▲ preparing review materials that summarize the basic skills and tools used in an instructional unit (assuming the unit did not have such a summary).

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8. Putting Mathematics to Work

See p. 43 for further clarification of this standard.

The student conducts at least one large scale investigation or project each year drawn from the following kinds and, over the course of high school, investigations or projects drawn from at least three of the kinds.

A single investigation or project may draw on more than one kind.

Data study, in which the student:
- **carries out a study of data relevant to current civic, economic, scientific, health, or social issues;**
- **uses methods of statistical inference to generalize from the data;**
- **prepares a report that explains the purpose of the project, the organizational plan, and conclusions, and uses an appropriate balance of different ways of presenting information.**

Mathematical model of a physical system or phenomenon, in which the student:
- **carries out a study of a physical system or phenomenon by constructing a mathematical model based on functions to make generalizations about the structure of the system;**
- **uses structural analysis (a direct analysis of the structure of the system) rather than numerical or statistical analysis (an analysis of data about the system);**
- **prepares a report that explains the purpose of the project, the organizational plan, and conclusions, and uses an appropriate balance of different ways of presenting information.**

Design of a physical structure, in which the student:
- **creates a design for a physical structure;**
- **uses general mathematical ideas and techniques in discussing specifications for building the structure;**
- **prepares a report that explains the purpose of the project, the organizational plan, and conclusions, and uses an appropriate balance of different ways of presenting information.**

Management and planning analysis, in which the student:
- **carries out a study of a business or public policy situation involving issues such as optimization, cost-benefit projections, and risks;**
- **uses decision rules and strategies both to analyze options and balance trade-offs; and brings in mathematical ideas that serve to generalize the analysis across different conditions;**
- **prepares a report that explains the purpose of the project, the organizational plan, and conclusions, and uses an appropriate balance of different ways of presenting information.**

Pure mathematics investigation, in which the student:
- **carries out a mathematical investigation of a phenomenon or concept in pure mathematics;**
- **uses methods of mathematical reasoning and justification to make generalizations about the phenomenon;**
- **prepares a report that explains the purpose of the project, the organizational plan, and conclusions, and uses an appropriate balance of different ways of presenting information.**

History of a mathematical idea, in which the student:
- **carries out a historical study tracing the development of a mathematical concept and the people who contributed to it;**
- **prepares a report that explains the purpose of the project, the organizational plan, and conclusions, and uses an appropriate balance of different ways of presenting information.**

Examples of investigations or projects include:

- analyzing selected newspapers and magazines for accuracy and clarity of graphical presentations of data, discussing the most common and effective types of presentation used, and identifying misleading graphical practices;
- carrying out a study of the circulation of books in a library over a period of time; representing the relative number of borrowers for each type of book and analyzing any change over time; representing the number of borrowers for the most popular book titles and looking for a correlation with the number of copies of each title the library has;
- constructing pendulums with various lengths of rods and masses of bobs; measuring their periods when released from various heights; determining which of these parameters the period depends on; creating a formula for the period in terms of these parameters; and comparing these results with the analysis of a pendulum in a physics book;
- analyzing the retrograde motion of the planet Mars as seen from Earth; consulting resources that give explanations of this phenomenon; considering its explanation in terms of epicycles in a geocentric system and its explanation in a heliocentric system; and giving a quantitative model based on circular orbits that predicts the retrograde motion;
- analyzing the characteristics of an irrigation system for large fields that has a central water feed and rotating spray arms that sweep out a circle;
- designing and making a model for a wheelchair access ramp to an 11′ high platform, given that the ramp must fit in a 30′ by 30′ space and must conform to the provisions of the Americans with Disabilities Act;
- designing seating plans for a large theater given specifications on the size and shape of the space, the allowable width of aisles, the required spacing between rows, and the allowable sizes and spacing of seats; finding the plan that allows for the maximum number of seats; suggesting how that plan might have to be modified to take other features into consideration, such as staggering seats in successive rows for better viewing;
- making a plan for the layout of a housing development to be created on a large tract of land, according to given specifications such as, lot size, house setbacks, and street widths, and taking into consideration given information on the relation between development cost and possible sale prices;
- solving the following problem: Create a schedule for a ping-pong tournament among 10 players in which each player plays each other player exactly once; arrange the schedule so that no players have to sit out while others are playing. Try to do the same for a tournament with 16 players. Then (this is much harder) say what you can about the general case of a tournament with 2n players. Create effective and revealing representations for the schedules *(see Balanced Assessment Project: see also Applied Learning Standard 1)*;
- reading and reporting on the history of the Pythagorean Theorem, including a discussion of some of the basic ways of proving the theorem and of its uses within and outside mathematics;
- carrying out a historical study of the concept of "function" in mathematics, including a report on the most important function concepts and types currently in use, basing part of the work on interviews with people from other fields who use mathematics in their work.

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Problem Solving and Mathematical Reasoning

The relationship of problem solving to concepts, to skills, to communication, and to reasoning

Solving a large grain-size problem can be seen as involving the three main "layers" sketched below. ***We characterize a "problem solving" task as one that makes a significant demand on the student in the first layer, the "big picture." Note that the outer layer is often harder than the middle one, which is harder than the inner one.***

The big picture
This is the "outer" layer. It consists of the general strategies involved in organizing an overall plan for formulating the problem, implementing a solution, and coming to some sort of closure. This layer is the subject of Standard 5, Problem Solving and Mathematical Reasoning.

The mathematical concepts
This is the "middle" layer. It consists of making correct use of the appropriate mathematical concepts in carrying out the overall plan. This layer is the subject of the four conceptual standards: Standard 1, Number and Operation Concepts; Standard 2, Geometry and Measurement Concepts; Standard 3, Function and Algebra Concepts; and Standard 4, Statistics and Probability Concepts.

The skills and tools
This is the "inner" layer. It consists of applying the techniques and carrying out the detailed computations and procedures required to implement the overall plan, using the selected mathematical concepts. This layer is the subject of Standard 6, Mathematical Skills and Tools.

This is a logical look at the overall process of engaging a problem and not a suggestion about the order in which things will be carried out or written up. Any actual solution process involves moving back and forth between general strategies, concepts, and skills, and any effective write-up involves an integrated presentation in which elements from all layers are intertwined. This leads to communication.

Communication
In the perspective being outlined here, communication does not belong to any particular "layer" but refers to the presentation of all three layers in a way that shows their relationship and provides a natural flow of ideas. A well communicated response will use appropriate representations (charts, maps, tables, diagrams, scale drawings, formulas, functions, graphs, equations, sample calculations) and will tie these together with concise wording that shows the purpose of each representation, relates it to the underlying mathematical concepts, and discusses its implications for the solution process.

Reasoning
Student work on problem solving tasks, even when it is carefully done and thoroughly revised, is not complete until it deals with justification of results: showing why things are. It is not sufficient for students to point out things they have noticed. For example, perhaps students have noticed that all numbers in a particular pattern are perfect squares. They need to go on to give a reason that explains this observation. For example, they might show why a property of perfect squares explains this pattern, e.g., that they have an even number of factors.

Standard 5, Problem Solving and Mathematical Reasoning, is intended as a coherent set of related ideas. Reasoning, manifested as conjecture, proof, and generalization, is essential to each of the three aspects of problem solving: formulation, implementation, and conclusion.

The three ingredients of problem solving

To be seen as a true problem solving experience, a task needs to make significant demands on the student in one or more of these three aspects of the solution process: formulation, implementation, and conclusion.

Problem formulation
The demand here is for the student to participate in the formulation of the problem to be solved. Often, a basic problem will have been posed in the task prompt, but the student will play a role in deciding on a precise interpretation of the problem (figuring out just what the problem asks for) and in gathering the elements needed to pursue the problem (deciding what to do to get started). This sort of demand is not present when a problem has been fully "scaffolded" for the student through a series of given questions that lead into the heart of the solution process.

Problem formulation is to be distinguished from problem posing. When a student is called on to pose a problem, the only prompt is a brief description of a phenomenon or situation to be investigated, leaving it up to the student to pose a definite problem based on this situation and then pursue it. This is more difficult than problem formulation as we are interpreting it. We expect that students will not have the requirement of problem posing in most problem solving situations.

Problem implementation
The basic demand here is for the student to play an active role in planning and carrying out a solution to the problem once it has been formulated. Tasks that explicitly lay out steps for the student to take do not involve this problem implementation demand. The student needs to choose appropriate organizing schemes, solution strategies, mathematical concepts, and reasoning techniques in carrying out a solution to the formulated problem.

We interpret problem implementation as involving three kinds of ideas:
- employing useful problem solving strategies;
- choosing and implementing appropriate mathematical concepts;
- applying mathematical concepts to new situations within and outside mathematics.

It is impossible and unnecessary to make a sharp dividing line between problem formulation and problem implementation.

Problem conclusion
The basic demand here is for the student to provide closure to the solution process through some sort of summary statements and general conclusions. This is necessary in all problems. In some problems the student may be called upon to provide additional closure through an evaluation and/or extension of the results or by relating the problem and its results to other problems solved in the past.

Problem types that call for problem solving

The essential requirements for a task to be "problem solving" are that the task is non-routine and that the task prompt does not lay out specific and detailed steps for the student to follow.

There are more direct ways of characterizing the types of task which capture the spirit of problem solving. One type is tasks which require a relatively high level use of relatively low level mathematical concepts. Such tasks call upon mathematics that the student may have known for years but require that the student figure out how to use this mathematics in new and more complex situations. Exercises and template tasks have the opposite characteristic. They require a relatively low level use of relatively high level (recently learned) concepts.

Other task types which frequently provide opportunities for problem solving are:
- tasks which require thoughtful strategy rather than direct application of known concepts;
- tasks in which the main challenge is creating a systematic plan for dealing with a complex situation;
- tasks which involve mathematical modeling of real world situations or situations from another field such as science or business;
- "open middle" tasks with a definite solution but many possible routes to this solution;
- tasks which require the problem solver to complete a sketched out formulation of the problem and then to decide what mathematics is to be used to solve it;
- tasks which require a new insight that cuts through a difficult hurdle, or tasks with a definite nut to crack and an "aha" experience when it is cracked;
- tasks which have at their heart an exploration or investigation of a rich but relatively unfamiliar situation in mathematics;
- tasks which require a creative and insightful use of familiar mathematical concepts;
- tasks which require a student to extend a known concept to new situations not previously studied.

Characterizing good problem solving tasks

Openness of tasks
A problem solving task should be open in the sense of allowing choices for the student. Still, any task regarded as problem solving must place specific and meaningful conditions on what a response must accomplish; for example, by specifying a clear purpose for the response or clear criteria that a solution must meet. Tasks that allow much latitude in approach without giving a clear sense of what is required of the final result may be good instructional vehicles, but they do not constitute problem solving in the sense in which we are using the term.

The experience of the problem solver
The experience of the problem solver needs to play a role in deciding what constitutes problem solving. A "problem solving task" is one that is new (the problem solver has not seen tasks similar to this) and non-routine (no routine extension of methods already seen will suffice to complete the task). What is a problem solving task for a younger student may be a routine application of concepts and skills for an older student. Similarly, what is a problem solving task for some students at a grade level would not be a problem solving task for others at that grade level who have had extensive experience with that particular type of task.

The problem solving load
A task that involves simple content, well known to the student, that needs to be applied in new and perhaps complex situations has a problem solving load that stems from the situation. On the other hand, a task that involves a very simple situation in which the student has to work out some mathematics that is not well known, difficult, and perhaps not yet studied, has a problem solving load that stems from the mathematical content. In other words, the problem solving load comes either from working with new or complex situations with known content, or from working with unfamiliar content with simple situations. The load should not be in both of these areas at once.

Problem solving content
Some problem solving tasks involve mathematical content outside the core curriculum, while others are tasks that require more an extended and organized application of common sense than any particular mathematical content. Either of these types of task can be valuable, but tasks using content from the core curriculum should constitute the majority of problem solving tasks students work on.

What problem solving should not mean
Certain other types of problems that have been put forth as problem solving in the past do not constitute problem solving in the sense in which we are using the term. These include trick problems or problems with a special technique useful only in a limited type of problem or problems which are sorted by problem solving strategy or problems which explicitly suggest to the student what strategy to use.

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Putting Mathematics to Work

The structure of a project

Each completed project includes the following parts:

Purpose
Here the student states a design objective, a research question, a focusing issue, and/or a conjecture to be investigated.

Implementation
Here the student formulates an organizational plan and carries it out. This will typically include collection and organization of information, mathematical analysis of the situation, justification of the choices and decisions made, and discussion of initial results.

Conclusion
Here the student summarizes the work, presents the final conclusions, and interprets the final results in light of the project's purpose.

The presentation of a project
A project needs an appropriate balance of different ways of presenting information and ideas. A presentation that forces everything into words, sentences, and paragraphs is as difficult to follow as one that includes only tables, graphs, and calculations. A balanced presentation chooses effective representations (such as charts, tables, pictures, diagrams, maps, formulas, equations, calculations, and graphs) and connects them with verbal exposition that clarifies their meaning, purpose, and relationship to one another.

Common threads in projects

Each type of project can be characterized by:

- the kinds of mathematics it uses, for example:
  - a data study uses statistics;
  - a mathematical model is often based on functions;
  - a design of a physical structure may use geometry;
  - a management analysis may use linear programming or decision theory.
- the kinds of generalization it tends to employ, for example:
  - a data study employs generalizations using methods of statistical inference;
  - a mathematical model employs generalizations based on the structure of the system being studied.
- the kinds of mathematical representations it calls for, for example:
  - a data study calls for tables and graphs;
  - a mathematical model calls for diagrams (often these are scale diagrams or diagrams analyzed through geometry) and symbolic representation of functions (often these are functions that describe the relationships in the diagrams);
  - a design of a structure calls for scale drawings and for formulas or geometric specification of its physical characteristics;
  - a management analysis calls for decision trees and flow charts.
- the purpose it serves, for example:
  - the purpose of a data study is to show trends and correlations;
  - the purpose of a mathematical model is to express succinctly the essential characteristics of a physical phenomenon or system;
  - the purpose of a design of a physical structure is to show how it could be built and once built how it would function to meet its specifications and purpose.

Examples of projects

(These examples are suggested by entries in portfolios that were discussed at the New Standards Portfolio meeting at Ascutney, Vermont, in July 1995.)

Data study
- A study of the circulation in a library based on type of book and number of users and showing the progression over a period of years.
- A study of the students in a district in terms of their proficiency in using writing in mathematics, and how that proficiency changed over a period of years.
- A study of several kinds of data about auto races and trends in these data over a number of years.

Mathematical model
- Analysis of the physics and mathematics of a pendulum, focusing on the relationship between period and length.
- Analysis of the change in shape undergone under thermal expansion of a long bridge.
- Analysis of the characteristics of an irrigation system with a central feed and a rotating spray mechanism that sweeps out a circle.

Design of a physical structure
- A plan for a housing development created according to given specifications, such as lot size, setback, and taking into consideration the relationship of development cost and possible sale prices.
- A plan for a wheel chair ramp conforming to legal specifications for such ramps and meeting the space and height requirements of a particular building.
- Design of an oval racetrack and marking of starting and finish lines for races of different lengths.

Management and planning analysis
- A business plan for publication of a magazine, taking account of different requirements in the production of the magazine, such as quality of paper, use of color, cover stock, and the relationship between selling price and circulation.
- A schedule for practices and events at the school gymnasium and swimming pool, taking account of home and away games, junior varsity and varsity, and boys' and girls' teams.

Pure mathematics investigation
- An investigation of the many properties of Pascal's triangle.
- An inquiry into what distributions of objects of two colors result in a probability of roughly ½ that the objects are the same color when two of the objects are selected at random. (For example, three of one color and six of another color is such a distribution.)
- A study of different mathematical types of spirals, the properties they share, and the ways in which they are different.

History of a mathematical idea
- A study of the history of the Pythagorean Theorem.

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Work Sample & Commentary: *Miles of Words*

1 Reading	2 Writing	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech Tools & Techniques	4 Learning & Self-mgmt Tools & Techniques	5 Tools & Techniques for Working With Others

Applied Learning

The quotations from the Mathematics performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 38–41.

The task

Students were given the following task:

Miles of Words

In this task you are asked to read a passage from a magazine article and then use mathematics to assess the reasonableness of its claim that forty thousand words were uttered in a 200 mile train journey.

The following appeared in *The New Yorker,* October 17, 1994:

I met Dodge on an Amtrak train in Union Station, Washington, in January of 1993.…He came into an empty car and sat down beside me, explaining that the car would before long fill up. It did. He didn't know me from Chichikov, nor I him.…Two hundred miles of track lie between Union Station and Trenton, where I got off, and over that distance he uttered about forty thousand words. After I left him, I went home and called a friend who teaches Russian literature at Princeton University, and asked her who could help me assess what I had heard.…

#1. Find a reasonable figure for the rate, in words per minute, of normal spoken language. Show all of your calculations and explain your reasoning.
#2. Make an estimate of the average speed of a train in miles per hour.
#3. Discuss in detail the statement: "over that distance he uttered about forty thousand words." Is this statement reasonable? Why or why not? Show all of your calculations and explain your reasoning.

The "Miles of Words" task was created by the Balanced Assessment Project. The text used is an excerpt from p. 80 of *The New Yorker* article "The Ransom of Russian Art" by John McPhee.

Circumstances of performance

The task "Miles of Words" was completed as an in-class individual assignment by a student in a high school geometry class. The student worked on the assignment for about 15 minutes. The response cited here is a first draft.

Mathematics required by the task

To get to the mathematical heart of the task, students first have to make sense of a written passage and then make reasonable estimates of the rate of speed s of a train (in miles per hour) and the rate r of normal speech (in words per minute). Having made these estimates, the task requires students to:

First, find the time T required to travel a given distance D at the estimated rate of speed s, using the relationship T = D/s;

Second, find the number of words N that can be spoken in that time T at the estimated rate r, using the relationship N = rT.

Combining the first and second steps gives the formula N = r(D/s), expressing the number of words N in terms of the estimated rate of speed s, the estimated rate of speech r, and the given distance D. Since s, r, and D are known, the formula can be used to see if the estimate of 40,000 words mentioned in the article is reasonable.

Students also need to make appropriate unit conversions: the time T they find in the first step will be in hours, and they will have to convert this to minutes before they use it in the second step where the rate is in "words per minute".

As individual exercises, these two steps would be too simple for high school. But the "Miles of Words" task requires students to do more than work routine exercises such as these. Students must formulate the problem from the context, make estimates, set up something equivalent to the steps set out above, and then combine them. What is being assessed in the task is this whole process.

The "Miles of Words" task helps answer these things about students' understanding:

Given a specific question based on a general context, can students figure out what information from the context is relevant and what mathematics is needed to answer the question? In this case the general context is an excerpt from a magazine article, and the mathematics is rate relationships.

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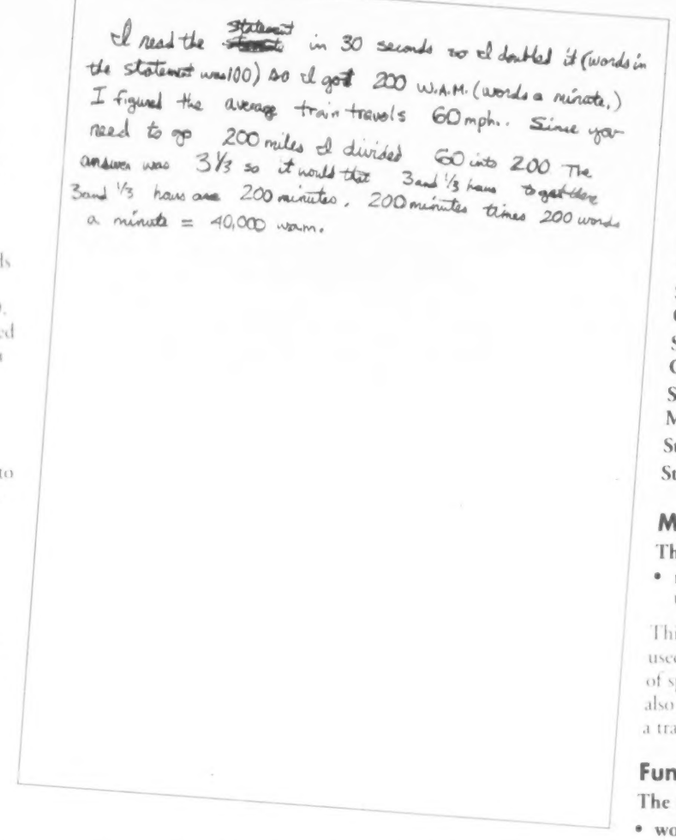
Can students work with the mechanics of these rate relationships and arrive at correct results that answer the given question?


I read the statement in 30 seconds so I doubled it (words in the statement was 100) so I got 200 W.A.M. (words a minute.) I figured the average train travels 60 mph. Since you need to go 200 miles I divided 60 into 200 The answer was 3 1/3 so it would take 3 and 1/3 hours to get there 3 and 1/3 hours are 200 minutes. 200 minutes times 200 words a minute = 40,000 words.

In short, the task requires students to formulate and set up a problem from a given context, and then solve the problem.

Another version of "Miles of Words" that was less scaffolded was also written. It used only question #3 from the task. Classroom trials revealed that the unscaffolded version, when given as an in-class assignment, presented a serious challenge to students. Apparently the direction provided by questions #1 and #2 of the scaffolded version played an important role in helping students formulate an approach to the problem. We recommend that teachers give their students the opportunity to attempt the unscaffolded version. Students might be invited to complete the task as a homework assignment so that they could have time to meet the challenge offered by the task.

This work sample provides evidence for the quality of work expected for parts of the following Mathematics standards:

Standard 2, Geometry and Measurement Concepts;

Standard 3, Function and Algebra Concepts;

Standard 5, Problem Solving and Mathematical Reasoning;

Standard 6, Mathematical Skills and Tools;

Standard 7, Mathematical Communication.

Mathematical Skills and Tools

The student:

- **makes reasonable estimates in appropriate units of quantities met in applications.**

This student has devised a simple method and used it to give a reasonable estimate of the rate of spoken speech (200 words a minute) and has also given a reasonable estimate of the speed of a train.

Function and Algebra Concepts

The student:

- **works with many kinds of rate relationships in constant rate situations.**

This student has found the time $3\frac{1}{3}$ hours (= 200 minutes) from the distance 200 miles and the rate 60 mph and has gone on to find the number of words 40,000 from the rate 200 words per minute and the time 200 minutes.

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The final result reads "w.a.m." (words a minute) instead of just "words." This appears to be a slip of the pen. The student earlier used "words a minute" correctly.

Geometry and Measurement Concepts

The student:

- **understands the structure of standard measurement systems, including… unit conversions.**

The student has converted hours to minutes at the appropriate point.

Mathematical Communication

The student:

- **presents mathematical results clearly, systematically, succinctly, and correctly.**

The response raises interesting questions about communication. In one sense, the student shows good communication abilities, since the response is clear, short, and to the point.

But the response is too cryptic to explain the ideas to someone who might not know how to approach the task. In this sense the response does *not* illustrate the following feature of Mathematical Communication:

- **explains mathematical concepts or ideas clearly to peers or others who may be having difficulty with them.**

The student has responded to the task's request to "explain your reasoning" in a way that meets the first criterion but not the second. A different version of the task (perhaps one that included the language of the second criterion) might have elicited a fuller response.

Problem Solving and Mathematical Reasoning

Problem formulation

The student:

- **fills out the formulation of a definite problem that is to be solved;**
- **extracts pertinent information from the situation as a basis for working on the problem.**

The response shows that the student has looked at the excerpt from the article, has focused on what is relevant to question #3 and has formulated and solved a particular problem involving rates.

Extensions

Once students have completed the task as given, an interesting question to ask is this: What is the "words per mile" rate w in the context of this "Miles of Words" task, and in general how does w depend on the speed of the train s in miles per hour and the rate of speech r in words per minute?

Students should be able to use basic dimensional analysis to reason that words per mile equals words per minute times minutes per mile. Minutes per mile is the reciprocal of miles per minute, and the latter is s/60 (since s is in miles per hour). In other words, $w = r \cdot \frac{60}{s}$. Using the figures of this student's response this would yield $w = 200 \cdot (60)/(60) = 200$ words per mile.

Ideas similar to those encountered in this task can be found in other contexts. One such task is the geometric related rates problem about shadows made by a moving person near a streetlight. See the examples of performance offered under Mathematics Standard 2.

Broader picture

Rate relationships are functional relationships, and the above way of extending the task brings in more ideas from algebra and the use of functions than the original task does. Work in response to this extension would illustrate these aspects of:

Function and Algebra Concepts:

The student:

- **represents functional relationships in formulas;**
- **defines and uses variables…in work with both functions and equations.**

In the traditional classroom treatment, rate relationships are often not presented in terms of functions. Instead, problems are ruled by the memorized formula "distance equals rate times time," or D = RT.

Here is how rate relationships can be looked at in terms of functions: Given a constant rate R, the distance traveled is a linear function of the time elapsed. The time can be represented by a variable t, and the function can be expressed as $D(t)=Rt$. For any given constant rate R this is a linear function of t, with a straight line graph through the origin. The slope of this line is the rate R. If the motion has a starting point D_0 or a starting time t_0 which is different from zero, then the general distance function becomes $D(t) = D_0 + R(t - t_0)$.

In the Netherlands, students "should be able to apply strategies relating to problem-analysis and reasoning,… [and] be able to estimate the outcome of a calculation or measurement and check the outcome for order of magnitude."

Mathematics: General and Core Objectives, p. 2.

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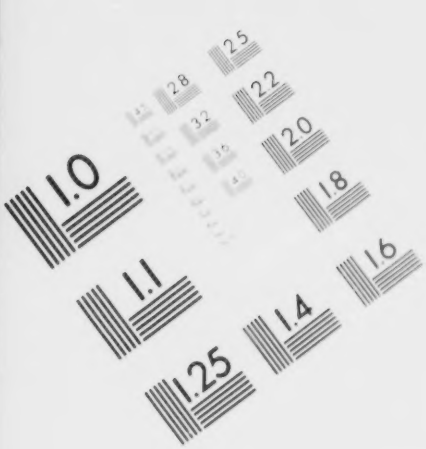

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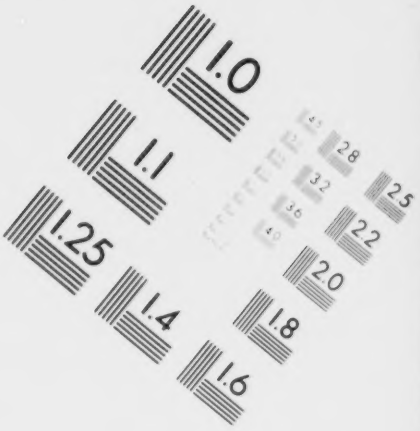

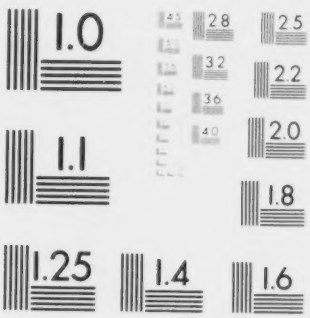

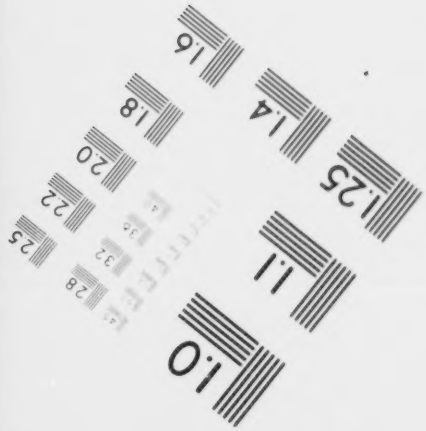

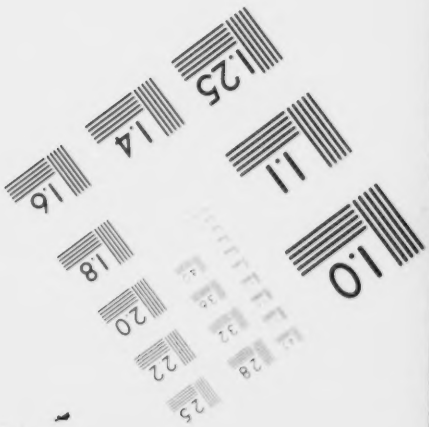

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Work Sample & Commentary: *Shopping Carts*

1 Reading	2 Writing	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech Tools & Techniques	4 Learning & Self-mgmt Tools & Techniques	5 Tools & Techniques for Working With Others

Applied Learning

The quotations from the Mathematics performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 38–41.

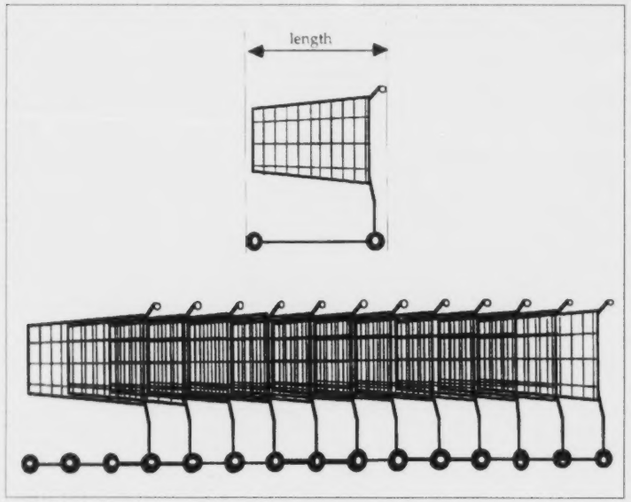
The task

Students were given the following task:

Shopping Carts

In this task you are asked to think mathematically about shopping carts. You are asked to create a rule that can be used to predict the length of storage space needed given the number of carts.

The diagram below shows a drawing of a single shopping cart. It also shows a drawing of 12 shopping carts that have been "nested" together. The drawings are accurately scaled to $\frac{1}{24}$th real size. (This diagram is reproduced at 58% of its original size.)



#1. Create a rule that will tell you the length S of storage space needed for carts when you know the number N of shopping carts to be stored. You will need to show HOW you built your rule; that is, we will need to know what information you drew upon and how you used it.

#2. Now create a rule that will tell you the number N of shopping carts that will fit in a space S meters long.

The "Shopping Carts" task was created by the Balanced Assessment Project.

Circumstances of performance

The task, "Shopping Carts," was completed as an in-class individual assignment by students in a second year algebra class. Students in the class were told that the task was "non-routine": the task was one that they would probably not have learned how to solve in class. Students were also told that they had probably learned all of the mathematics that was needed to solve the task. Students worked on this assignment for about 45 minutes. The response reproduced here is a first draft. It is clear from what the student says that a revised response would be shorter and more direct.

Mathematics required by the task

Scale

There are two relevant lengths in this task. One is the full length (call it L) of a single cart, and the other is the amount (call it d) that each new cart in a row sticks out beyond the others. Since the drawing is accurately scaled to $\frac{1}{24}$th full size, L and d can be found by measuring the drawing and multiplying by 24.

Discrete linear function

In the "Shopping Carts" situation, each new cart added to a row adds the fixed amount d to the length of the row. This means that the length S of a row of carts is a linear function of the number n of carts in the row, and that the slope of this function is d. Since the full length of a single cart is L, this function can be written as

$$S = L + d(n-1).$$

Using the full-size measurements in centimeters of L and d for the shopping cart pictured, the function is

$$S = 96 + 28.8(n-1).$$

The reason n-1 appears in this formula instead of n is that the contribution of the first cart is contained in the number L. A way of writing the function using n instead of n–1 is

$$S = (L-d) + dn = 67.2 + 28.8n.$$

It is important to note that the function here is discrete, i.e., it is meaningful in this context only for the natural numbers n = 1, 2, 3,.... In particular, n = 0 gives a result, S = L–d, which has no direct meaning in this context, because it would mean the length of a row of 0 carts.

Students study proportional relationships starting in middle school. By high school they are also studying linear functions, which are the mathematical tools needed to describe proportional relationships. This task is designed to see if students can recognize the proportional relationship inherent in this situation, i.e., the proportional relationship between the increase in the length of a nested row of carts and the number of carts added, and then go on to express that relationship in terms of a linear function.

This work sample provides evidence for the quality of work expected for parts of the following Mathematics standards:

Standard 2, Geometry and Measurement Concepts;

Standard 3, Function and Algebra Concepts;

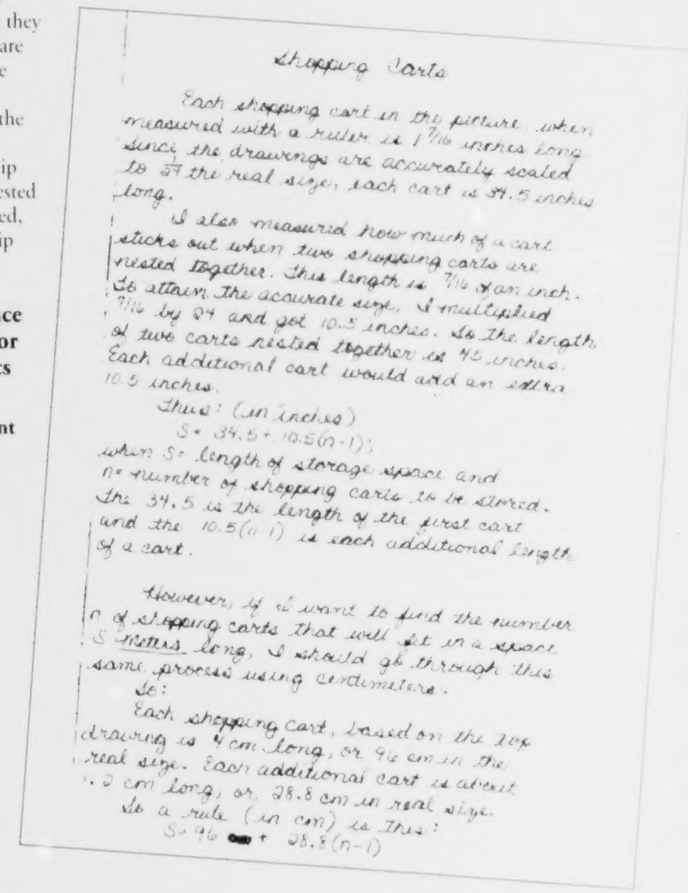
Standard 7, Mathematical Communication.

Geometry and Measurement Concepts

The student:

- **works with geometric measures of length...;**
- **solves problems involving scale and change of scale in maps and diagrams.**

This student has recognized the two lengths needed to work the problem, measured them from the diagram, and used the given $\frac{1}{24}$th scale of the diagram to convert these to full size measurements.



Shopping Carts

Each shopping cart in the picture, when measured with a ruler is 1 7/16 inches long since the drawings are accurately scaled to 1/24 the real size, each cart is 34.5 inches long.

I also measured how much of a cart sticks out when two shopping carts are nested together. This length is 7/16 of an inch. To attain the accurate size, I multiplied 7/16 by 24 and got 10.5 inches. So the length of two carts nested together is 45 inches. Each additional cart would add an extra 10.5 inches.

Thus: (in inches)

S = 34.5 + 10.5(n-1);

when S = length of storage space and n = number of shopping carts to be stored. The 34.5 is the length of the first cart and the 10.5(n-1) is each additional length of a cart.

However, if I want to find the number n of shopping carts that will fit in a space S meters long, I should go through the same process using centimeters.

So:

Each shopping cart, based on the 1/24 drawing is 4 cm long, or 96 cm in the real size. Each additional cart is about 1.2 cm long, or 28.8 cm in real size.

So a rule (in cm) is Thus:

S = 96 + 28.8(n-1)

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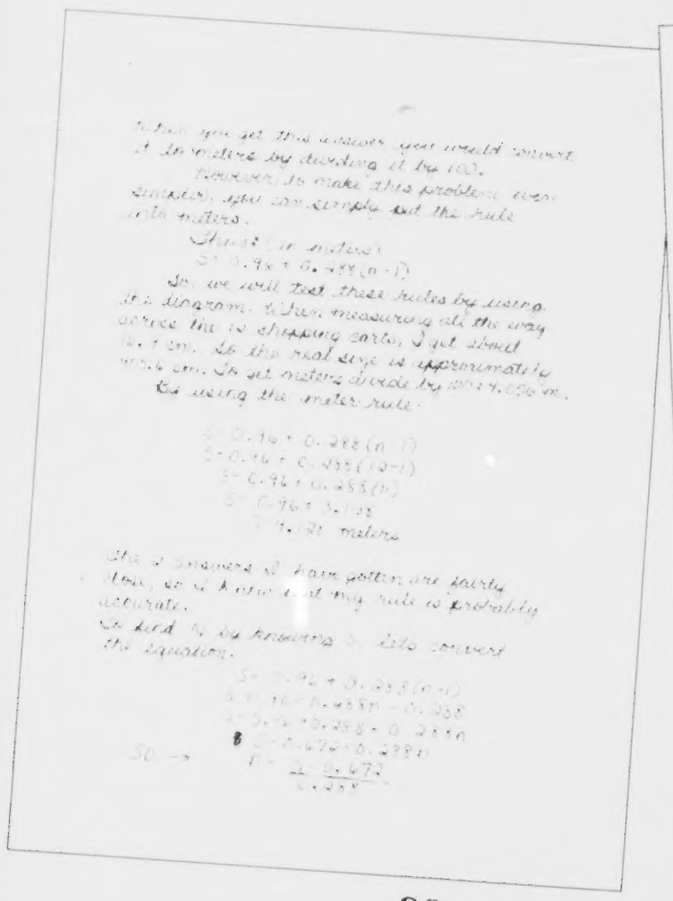
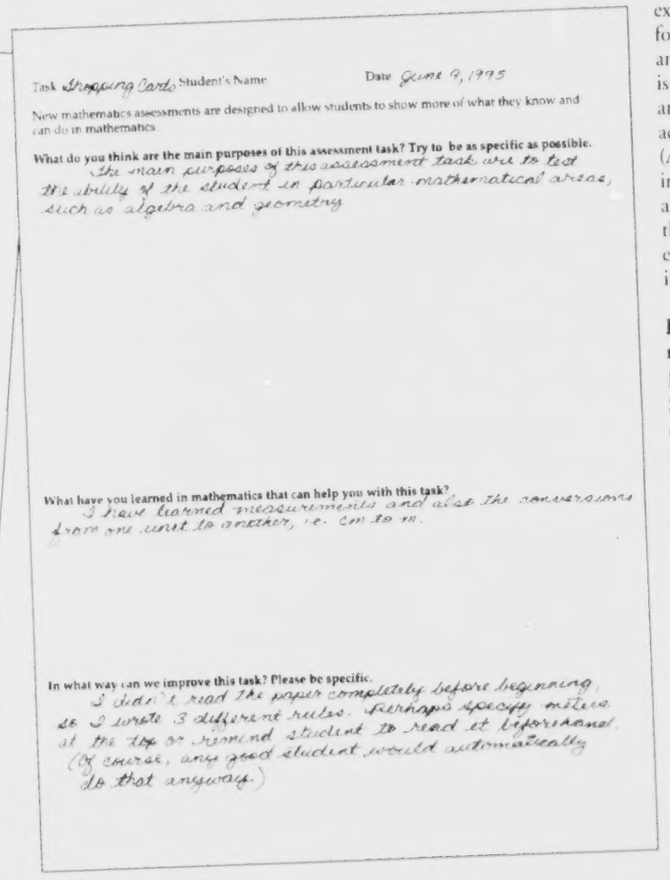
The student started with customary units (inches) but then changed to metric when question 2 called for meters. The following extract from the student's reflection on the task indicates that if she were to revise it, she would use metric from the start and said as much to the teacher on the reflection sheet: "I didn't read the paper completely before beginning so I wrote 3 different rules. Perhaps specify meters at the top or remind students to read it beforehand (Of course any good student would automatically do that anyway.)"




Task Shopping Carts Student's Name Date June 9, 1995
New mathematics assessments are designed to allow students to show more of what they know and can do in mathematics.
What do you think are the main purposes of this assessment task? Try to be as specific as possible.
The main purposes of this assessment task are to test the ability of the student in particular mathematical areas, such as algebra and geometry
What have you learned in mathematics that can help you with this task?
I have learned measurements and also the conversions from one unit to another, i.e. cm to m.
In what way can we improve this task? Please be specific.
I didn't read the paper completely before beginning so I wrote 3 different rules. Perhaps specify meters at the top or remind student to read it beforehand. (Of course, any good student would automatically do that anyway.)

Of course, there is in general no need to start from scratch to change a result to metric. Using conversion factors from customary to metric will accomplish the same thing.

Function and Algebra Concepts

The student:

- **models given situations with linear… functions and interprets given functions in terms of situations;**
- **defines and uses variables, parameters, constants, and unknowns in work with both functions and equations;**
- **solves equations both symbolically and graphically, especially linear, quadratic, and exponential equations.**

Modeling

The student has created a simple function that describes the given situation. The student has also been clear about interpreting the mathematics in terms of the situation, for example, by constructing the formula S = 34.5 + 10.5(n–1) and then saying that "the 34.5 is the length of the first cart and the 10.5(n–1) is each additional length of a cart." (Actually, the 10.5(n–1) inches is the length added by all the additional carts after the first. The length added by each additional cart is 10.5 inches.)

Functions, equations, and re-expression

Having expressed the length S in terms of the number n of carts, using the function S = 96 + 28.8(n–1), the student knows to solve this equation for n in terms of S to express the number n in terms of the length S.

Mathematical Communication

The student:

- **presents mathematical procedures and results clearly, systematically, succinctly, and correctly.**

The student has clearly and concisely explained the steps of the solution process. This is especially noteworthy given that the work is a first draft done in an on-demand, in-class setting.

Extensions

Once students have completed the task as given, it is interesting to ask them to look for other examples in the real world of structures which, similar to a row of nested shopping carts, can be represented by linear functions of the form

$$y = A + bn.$$

There are many such examples, e.g., stacks of paper cups. In the examples students might offer, y, A, and b should have a clear geometric meaning that the students identify; n should represent the number of identical components in the structure. Then the examples can be represented in a diagram similar to the shopping carts diagram.

Russian secondary school students are expected "to systematize and develop their knowledge of functions as important mathematical models, of properties of numerical functions and ways of depicting them, of graphs of functions as visual representations of functional dependencies, of the content and the applied value of the task of examining functions."

The Provisional State Education Standard, General Secondary Education, Mathematics, p. 47.

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Work Sample & Commentary: *Grazing Area*

1	2	3	4	5	6	7
Reading	Writing	Speaking, Listening & Viewing	Conventions, Grammar & Usage	Literature	Public Documents	Functional Documents

English Language Arts

1	2	3	4	5	6	7	8
Number & Operation Concepts	**Geometry & Measurement Concepts**	Function & Algebra Concepts	Statistics & Probability Concepts	**Problem Solving & Mathematical Reasoning**	**Mathematical Skills & Tools**	**Mathematical Communication**	Putting Mathematics to Work

Mathematics

1	2	3	4	5	6	7	8
Physical Sciences Concepts	Life Sciences Concepts	Earth & Space Sciences Concepts	Scientific Connections & Applications	Scientific Thinking	Scientific Tools & Technologies	Scientific Communication	Scientific Investigation

Science

1	2	3	4	5
Problem Solving	Communication Tools & Techniques	Information Tech. Tools & Techniques	Learning & Self-mgmt Tools & Techniques	Tools & Techniques for Working With Others

Applied Learning

The quotations from the Mathematics performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 38–41.

The task

The task is given in the first paragraph of the work sample.

Circumstances of performance

The student work presented here is an excerpt from a long term project that was completed over a four week period. During this time, one class per week was allocated to completion of the project. Students worked in groups of three or four with no help from the teacher or other adults. Each student produced a separate write-up. The full project comprised six different scenarios. One student's solution to the first of these is discussed here. The project was included by the student in a portfolio of work in mathematics.

Mathematics required by the task

The task requires understanding of the Pythagorean Theorem, some basic right triangle trigonometry, and methods for finding the area of a triangle and the sector of a circle:

- finding lengths:
  - knowing the length of the hypotenuse of a 45° right triangle, find the length of a side;
  - knowing the lengths of two sides of a right triangle, use the Pythagorean Theorem to find the length of the hypotenuse;
- finding angles:
  - knowing two angles of a triangle, find the third; knowing two out of three angles that form a straight angle, find the third; find the angle of a sector of a circle, knowing the angle of the complementary sector;
  - knowing the length of two sides of a right triangle, use the inverse of the tangent function to find the acute angles;
- finding areas:
  - knowing the base and height of a triangle, find its area;
  - knowing the angle and radius of a sector of a circle, find its area.

The "modeling" demands of the task are greater than the demands of the mathematical content itself (the lengths, angles, and areas). In their modeling, students need to analyze the situation carefully, set up the appropriate diagrams themselves, and decide on a sequence of specific mathematical procedures to follow, keeping in focus the complex interrelationship between the parts of the problem. This modeling requirement, not the difficulty of the content, is what goes far beyond typical problems from texts.

Notice that the model selected represents a simplification of the real situation, as many models do. In a real situation one would have to be concerned about the height of the rope off the ground, whether it was parallel to the ground, what type of collar the cow had, and other details. Still, even though it is a simplification, the given model is quite instructive. It uses mathematical ideas powerfully to solve an easily visualized but complicated problem.

Although the context of this task is fanciful, its solution requires a solid understanding of geometry. Versions of this task have been around for many years as puzzle problems or problem solving activities.

This work sample provides evidence for the quality of work expected for parts of the following Mathematics standards:

Standard 2, Geometry and Measurement Concepts;

Standard 5, Problem Solving and Mathematical Reasoning;

Standard 6, Mathematical Skills and Tools;

Standard 7, Mathematical Communication.

Problem Solving and Mathematical Reasoning

Problem formulation

The student:

- **fills out the formulation of a definite problem that is to be solved;**
- **extracts pertinent information from the situation as a basis for working on the problem;**
- **asks and answers a series of appropriate questions in pursuit of a solution and does so with only minimal "scaffolding" in the form of detailed guiding questions.**

Problem implementation

The student:

- **chooses and employs effective problem solving strategies in dealing with non-routine and multi-step problems;**
- **selects appropriate mathematical concepts and techniques from different areas of mathematics and applies them to the solution of the problem;**
- **applies mathematical concepts to new situations within mathematics and uses mathematics to model real world situations involving basic applications of mathematics…**

The student has started with only a general description of the situation (a cow on a fifty foot rope a certain distance from a barn of given dimensions), and has formulated and implemented a detailed plan for solving the problem (finding the grazing area).

Geometry and Measurement Concepts

The student:

- **works with many types of figures and their properties, including polygons and circles…;**
- **knows, uses, and derives formulas for area… of many kinds of figures;**
- **works with similar triangles and extends the ideas to include definitions and simple uses of the three basic trigonometric functions;**
- **works with geometric measures of length, area, surface area, volume, and angle…;**
- **models situations geometrically to formulate and solve problems.**

Geometry

The student has selected and used appropriately several key ideas from geometry, in finding lengths (properties of 45° right triangles), finding angles (the angle sum property in triangles), and in finding areas (of triangles and sectors of circles).

Trigonometry

There is one place where trigonometry is necessary in this task. It is a straightforward use: the two legs of a right triangle are known, and the sizes of the acute angles are needed. This is a simple step on a calculator, using the inverse operation for the tangent function, and the student has done this.

Note that on line seventeen of the student's response, there is clearly a "misprint." The student writes: "Next I figured out the hypotenuses of both triangles by solving the equation tan x = (opp)/(adj)." It is "angles" rather than "hypotenuses" that is intended.

Mathematical Communication

The student:

- **presents mathematical procedures and results clearly, systematically, succinctly, and correctly;**
- **describes and discusses mathematical ideas effectively both orally and in writing.**

At the end of the response, the student clearly lays out the diagrams and calculations used in solving the problem, preceded by a full exposition that leads the reader through the whole process.

This student's presentation clearly separates the prose exposition at the beginning from the diagrams and calculations at the end. An alternative presentation might have integrated the exposition with the diagrams and calculations. This would have made the whole piece of work easier to follow.

Further, this student's exposition is longer than mere clarity would dictate, largely because of the tendency to put into words things that could be better expressed by reference to a diagram. For example: "In order to procede [sic] in my calculations, I deemed it necessary to find the measures of the angles (in both DA and DB) opposite the 10' post side." Note that "procede" should be "proceed." There are a few other spelling errors in the work.

In short, once the mathematics was done (the diagrams and calculations), the student made the work into a portfolio entry by introducing the mathematics with a narrative. Another model for portfolio entries is writing that integrates mathematical representations and prose exposition and that takes the form of succinct explanation rather than running narrative.

The above comments should not detract from the judgment about the overall quality of the work. The student's response to this demanding problem is clear, well communicated, and correct. The "Reflection" written by the student gives some indication of the

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value she gained from the considerable effort put in. This student has done an impressive piece of mathematics and has written about it in a way that shows strong command of the subject.

Mathematical Skills and Tools

The student:

- **computes accurately using arithmetic and algebraic operations on whole and rational numbers, using both pencil and paper and technology;**
- **makes reasonable estimates in appropriate units of quantities met in applications;**
- **uses basic geometric terminology accurately and deduces information about basic geometric figures in solving problems;**
- **makes and uses rough sketches, schematic diagrams, or precise scale diagrams to enhance a solution;**
- **carries out numerical calculations and symbol manipulations effectively, using mental computations, pencil and paper, or technological aids, as appropriate.**

There are numerous places within this piece of work where the student demonstrates command over basic mathematical procedures in the strongest possible way: by choosing which procedures to use and then applying them correctly.

Estimation

In a complex piece of work it is good to check that the final numerical answer is in the right ballpark. This student happened not to do this. One way of checking the final numerical answer would be to observe that the total grazing area must be less than about 7,854 sq. ft., which is the area of a circle with radius 50 ft. and the size of the grazing area with no obstructions. Also, the total grazing area must be greater than three quarters of this area (about 5,890 sq. ft.), because there is no obstruction from the barn for more than three quarters of this circle. Indeed the final result, about 6,931 sq. ft., does lie comfortably within these limits.

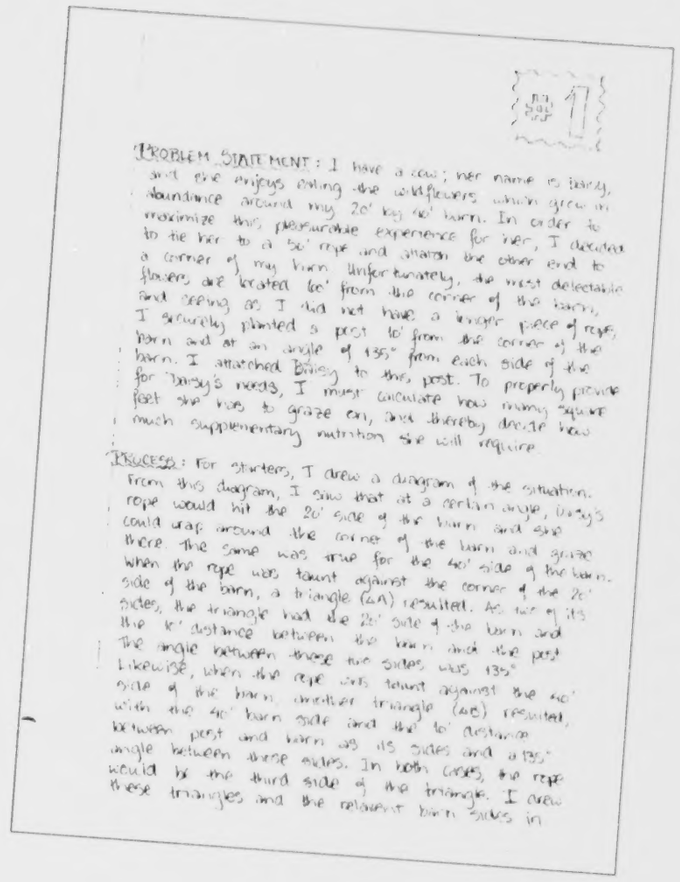
Extensions

There are many possible variants of this task depending on the length and placement of the rope and the size and shape of the obstruction (the barn). In fact, the work presented here is one of six variants that were part of the student's portfolio.

An optimization task

Here is another extension that is not one of the traditional variants but is one that connects the task much more strongly with the idea of expressing relationships in the form of functions:

Consider a cow on a 50′ rope which is attached to the side of a 20′ by 40′ barn. Express the grazing area as a function of the location of the end of the rope. (For example, let x represent the distance of the end of the rope from one of the corners of the barn, measured clockwise around the perimeter, where x can take on values from 0 to 120′, and let A(x) be the grazing area for location x.) Graph this function, and locate the maximum and minimum values. Are the locations on the barn that give rise to maximum and minimum areas special in any way? Give reasons that don't depend on detailed computation for why the maxima and minima are located where they are.



PROBLEM STATEMENT: I have a cow; her name is Daisy, and she enjoys eating the wildflowers which grow in abundance around my 20' by 40' hay ox' barn. In order to maximize this pleasurable experience for her, I decided to tie her to a 50' rope and station the other end to a corner of my barn. Unfortunately, the most delectable flowers are located 60' from this corner of the barn, and seeing as I did not have a length piece of rope, I securely planted a post 10' from the corner of the barn and at an angle of 135° from each side of the barn. I attached Daisy to the post. To properly provide for Daisy's needs, I must calculate how many square feet she has to graze on, and thereby decide how much supplementary nutrition she will require.

PROCESS: For starters, I drew a diagram of the situation. From this diagram, I saw that at a certain angle, Daisy's rope would hit the 20' side of the barn and she could wrap around the corner of the barn and graze there. The same was true for the 40' side of the barn. When the rope was taunt against the corner of the 20' side of the barn, a triangle (ΔA) resulted. As two of its sides, the triangle had the 20' side of the barn and the 10' distance between the barn and the post. The angle between these two sides was 135°. Likewise, when the rope was taunt against the 40' side of the barn another triangle (ΔB) resulted, with the 40' barn side and the 10' distance between post and barn as its sides and a 135° angle between these sides. In both cases, the rope would be the third side of the triangle. I drew these triangles and the relevant barn sides in

Japanese students are expected to "deepen their understanding of numbers, algebraic expression, functions, and geometrical figures, and encourage mastery of basic knowledge and skills, thereby increasing their abilities to use them correctly in the consideration of various phenomena."

Course of Study for Upper Secondary Schools in Japan, p. 40.

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Work Sample & Commentary: *Grazing Area continued*

1 Reading	2 Writing	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

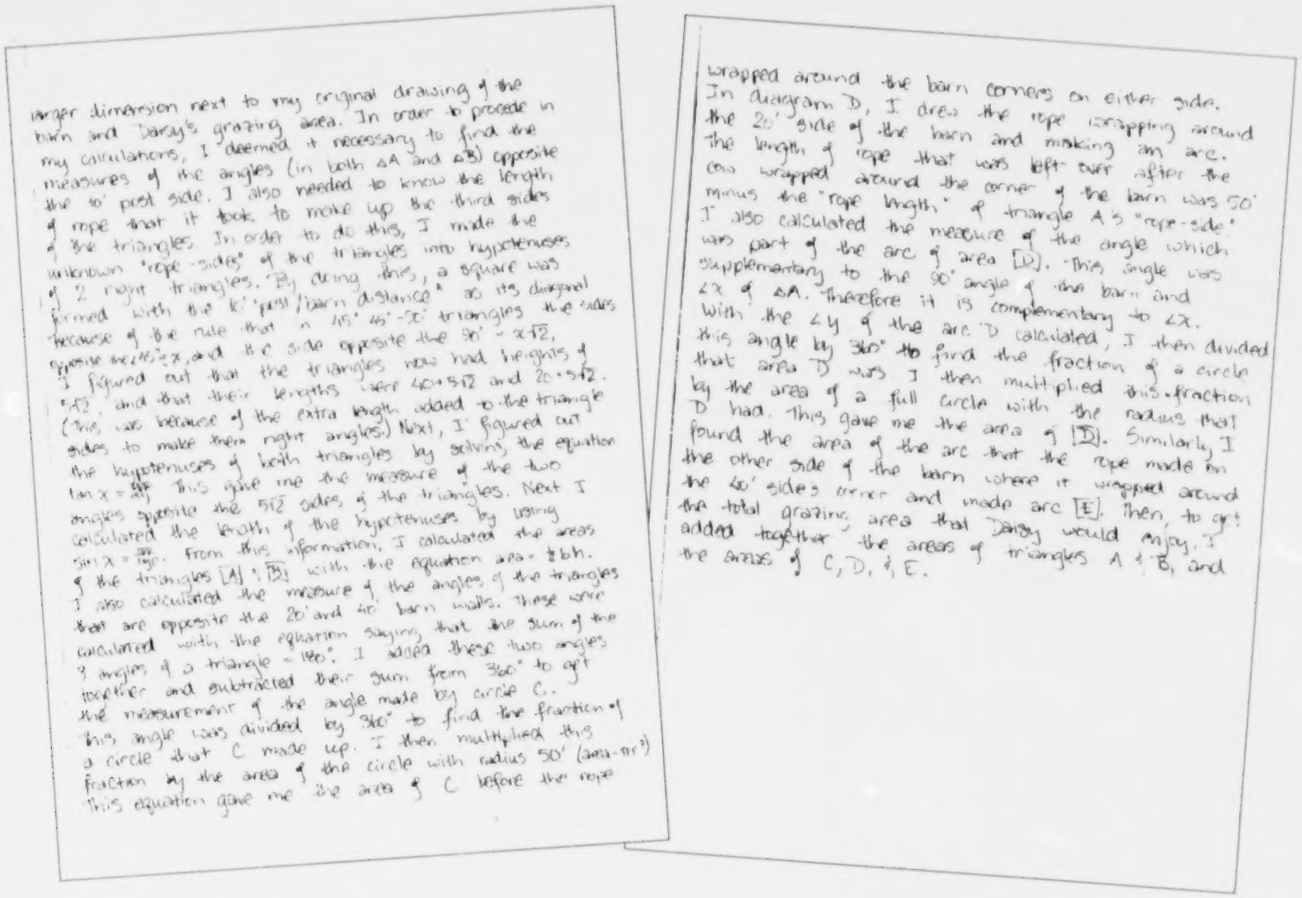
Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech Tools & Techniques	4 Learning & Self-mgmt Tools & Techniques	5 Tools & Techniques for Working With Others

Applied Learning



larger dimension next to my original drawing of the barn and Daisy's grazing area. In order to procede in my calculations, I deemed it necessary to find the measures of the angles (in both △A and △B) opposite the 50' post side. I also needed to know the length of rope that it took to make up the third sides of the triangles. In order to do this, I made the unknown "rope-sides" of the triangles into hypotenuses of 2 right triangles. By doing this, a square was formed with the 50' post/barn distance as its diagonal because of the rule that in 45°-45°-90° triangles the sides opposite the 45°'s = x and the side opposite the 90° = $x\sqrt{2}$. I figured out that the triangles now had heights of $\frac{50}{\sqrt{2}}$ and that their lengths were $40+\frac{50}{\sqrt{2}}$ and $20+\frac{50}{\sqrt{2}}$. (This was because of the extra length added to the triangle sides to make them right angles.) Next, I figured out the hypotenuses of both triangles by solving the equation $\tan x = \frac{\text{opp}}{\text{adj}}$. This gave me the measure of the two angles opposite the $\frac{50}{\sqrt{2}}$ sides of the triangles. Next I calculated the length of the hypotenuses by using $\sin x = \frac{\text{opp}}{\text{hyp}}$. From this information, I calculated the areas of the triangles [A] & [B] with the equation area = $\frac{1}{2}bh$. I also calculated the measure of the angles of the triangles that are opposite the 20' and 40' barn walls. These were calculated with the equation saying that the sum of the 3 angles of a triangle = 180°. I added these two angles together and subtracted their sum from 360° to get the measurement of the angle made by circle C. This angle was divided by 360° to find the fraction of a circle that C made up. I then multiplied this fraction by the area of the circle with radius 50' (area = πr^2). This equation gave me the area of C before the rope wrapped around the barn corners on either side. In diagram D, I drew the rope wrapping around the 20' side of the barn and making an arc. The length of rope that was left over after the cow wrapped around the corner of the barn was 50' minus the "rope length" of triangle A's "rope-side". I also calculated the measure of the angle which was part of the arc of area [D]. This angle was supplementary to the 90° angle of the barn and ∠x of △A. Therefore it is complementary to ∠x. With the ∠y of the arc D calculated, I then divided this angle by 360° to find the fraction of a circle that area D was. I then multiplied this fraction by the area of a full circle with the radius that D had. This gave me the area of [D]. Similarly, I found the area of the arc that the rope made on the other side of the barn where it wrapped around the 40' side's corner and made arc [E]. Then, to get the total grazing area that Daisy would enjoy, I added together the areas of triangles A & B, and the areas of C, D, & E.

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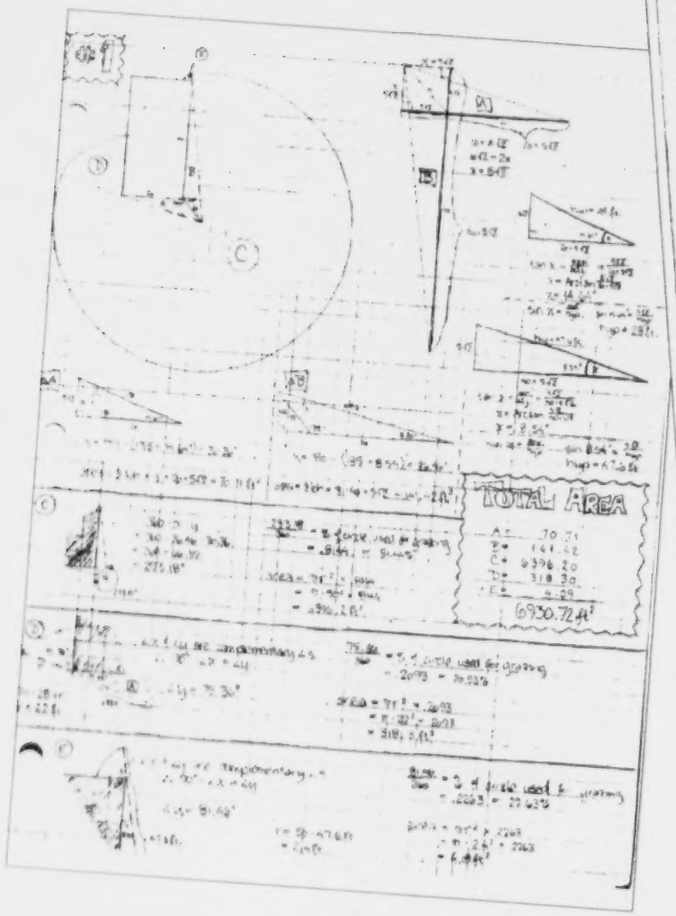

REFLECTION: From this problem I learned how to combine many mathematical techniques to solve a rather complex problem. Each aspect tied together to form a web with delicate bridges from problem to answer. These bridges were the tools I used, and each problem to answer had several routes that could be taken to get there. I also learned to go back and check my answers using different bridges.

I really enjoyed working with circles, and triangles and my ever trusty TI 85. This problem gave me a feeling for the real use of arcs, sine, cosine, and circles. I also learned that math can be fun and entertaining.

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Work Sample & Commentary: *Designing a Theater*

1 Reading	2 Writing	3 Speaking Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech. Tools & Techniques	4 Learning & Self-mgmt Tools & Techniques	5 Tools & Techniques for Working With Others

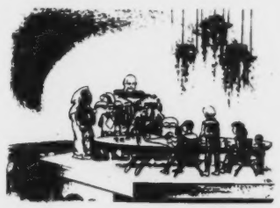
Applied Learning

The quotations from the Mathematics performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 38–41.

The task

Students were given the following task:

Designing a Theater for Galileo



You and your architectural engineering team are competing for the contract to design the new circular theater. The theater is to be built beneath the great dome *R 3* at the lunar space port Galileo. The Arts Director of Galileo has asked each potential engineering team to submit its design and its calculations for the new circular theater with revolving center stage. Although overall design is important, the job will go to the team that demonstrates the design with the greatest seating capacity. The director has given you the following restrictions and guidelines:

1. The theater must be only one level and seat at least a thousand people.
2. The stage should be at least ten meters in diameter.
3. The outer diameter of the theater interior should be at most 42 meters.
4. The seating should be divided into sections by equally spaced aisles radiating from center stage. There should be no fewer than four radial aisles and no more than eight radial aisles. Each radial aisle should be at least one meter in width.
5. There should be two concentric aisles. The innermost concentric aisle about the stage should be at least one meter wide and at most two meters wide. The outer concentric aisle should be at least two meters wide and at most four meters wide and ring the perimeter of the theater.
6. Safety codes at the lunar colony require that each seat be at least 60 centimeters wide and that each seating position be at least 90 centimeters in depth.
7. Safety codes require that there be no more than 30 seats in any row.

Your job is to draw a scaled plan of the theater (including seating, aisles, and stage). Your plan should maximize seating capacity. You should be able to support your design with calculations verifying your seating capacity. You will need to calculate:

1. The number of rows and the number of seats in each row.
2. The width at the stage end of each radial aisle and the width at the back end of each radial aisle. The width of the concentric aisles.
3. Total seating capacity for your plan.

The task is taken from Michael Serra's *Discovering Geometry*, Berkeley: Key Curriculum Press, 1989, pp. 292–293.

Circumstances of performance

The work presented here is a project that was completed over a four week period by a high school geometry student. No class time was allocated to completion of the project. Students worked in groups of three or four. Each student did a separate write up.

Mathematics required by the task

This is a design task. Students were asked to create a design, in this case for a theater, that conforms to several given specifications requiring ideas from geometry to interpret and implement. Perhaps the hardest part of the task is the requirement that the design created must seat the greatest number of people given the specified constraints. A surprising aspect of the task, brought out clearly in the student work, is the extent to which it involves parts of Standard 3, Function and Algebra Concepts, as well as parts of the more expected Standard 2, Geometry and Measurement Concepts.

The task requires students to do careful work based on the geometry of circles:

1. Lay out a circular central stage (at least 10 meters in diameter) surrounded by an aisle, an outside aisle, and a circular wall (no more than 42 meters in diameter).
2. Lay out a set of concentric circular rings that will serve as rows of theater seats, subject to a given minimum depth of a row (90 centimeters).
3. Divide the rings into sections with regularly spaced radial aisles, subject to a given minimum aisle width (1 meter), and calculate the length of the seating section in each row.
4. Calculate the number of seating positions possible in each seating section, subject to given minimum seat width (60 centimeters) and a given maximum number of seats per section (30).
5. Make use of the idea of "greatest integer less than or equal to s" when calculating the number of seats, since the number of seats must be an integer.

Further, the task requires students to do some optimization, since "the job will go to the team that demonstrates the design with the greatest seating capacity." The core mathematical concepts needed are few and simple. They are principally:

1. Find the circumference C of a circle from its radius r ($C = 2\pi r$).
2. Find the number N of seats allowed in a section of given length L meters under the constraint that there is a minimum of .6 meter allowed per seat: N = L/.6 seats. (This number must be rounded down to an integer value since the number of seats must be an integer.)

Taken in isolation, these concepts are straightforward, yet students need to use them repeatedly and appropriately in a complex situation. Since this need provides much more of a challenge than the concepts themselves, the task requires quite a bit of problem solving: understanding the situation, constructing and testing mathematical models of the situation, and choosing an optimal solution.

This work sample provides evidence for the quality of work expected for parts of the following Mathematics standards:

Standard 2, Geometry and Measurement Concepts;

Standard 3, Function and Algebra Concepts;

Standard 5, Problem Solving and Mathematical Reasoning;

Standard 7, Mathematical Communication.

Mathematical Communication

The student:

- **presents mathematical procedures and results clearly, systematically, succinctly, and correctly.**

The presentation is clear and easy to follow. It leads directly to the formula at the top of the second page and to the following table which was created using the formula. The components of the formula and table are clearly labeled.

The student has produced a clear explanation of the steps that produced the design, a formula for the crucial calculation of the number of seats in a row, and a useful diagram showing the final plan.

The communication does have some minor flaws. Singular and plural forms are interchanged, e.g., "meter" and "meters," "radius" and "radii"; and "+" appeared in the table in some places where "–" was appropriate.

Problem Solving and Mathematical Reasoning

Problem implementation

The student:

- **chooses and employs effective problem solving strategies in dealing with non-routine and multi-step problems;**
- **selects appropriate mathematical concepts and techniques from different areas of mathematics and applies them to the solution of the problem;**
- **applies mathematical concepts to new situations within mathematics and uses mathematics to model real world situations involving basic applications of mathematics in the physical sciences, the social sciences, and business.**

The student has made a good start at modeling mathematically the theater design problem. This is a moderately complex task and requires significant problem understanding, formulation, and execution.

On the other hand, there are some aspects of the work which do not illustrate the quality required for Problem Solving and Mathematical Reasoning. For example, the student chooses 1.5 meters for each row, much more than the 0.9 meter minimum, but is then able to fit in only 8 rows. The total number of seats obtained in this way (966) falls short of the stated minimum of 1,000. Clearly this should have been addressed by using an amount less than 1.5 meters per row.

There is another way in which the work fails to meet fully the modeling requirements of Problem Solving and Mathematical Reasoning. Actually making a design requires many choices regarding the number and width of aisles, the number of rows, and the width per seating place. These all interact, and considerable reasoning is required to sort out the implications of the choices. Unfortunately, the student does not justify the choices made or discuss the interactions. Balancing these sorts of issues and justifying choices is at the heart of the task. This student shows too little evidence of having grappled with them.

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Geometry and Measurement Concepts

The student:

- **works with many types of figures and their properties, including polygons and circles.**

The student uses the geometry of circles to figure out the dimensions of the circular rings that form each row of seats. The radii of the rings are chosen to give sufficient space for each row and for the central stage, the circumferences of the rings are computed, and the rings are divided into six sections by placing six radial aisles.

In one respect, the geometry work did not quite match the requirements of the task. Specifically, the student uses the circle bounding the rear of each row in making the calculation of .6 meter of width per seat. But this will make the front of the resulting seat spaces narrower than this required minimum since they are wedge shaped. This difficulty would have been avoided if the circle bounding the front of each row had been used in making the .6 meter per seat calculation.

Function and Algebra Concepts

The student:

- **models given situations with linear, exponential, or quadratic functions and interprets given functions in terms of situations;**
- **represents functional relationships in formulas.**

The formula produced at the top of the second page is the heart of the student's response. The formula is clearly labeled as giving the "# of seats in a row for each section," and the components are also labeled. This formula provides an effective mechanism for counting the number of seats in each row in terms of the radius of the row and also for assuring that the number of seats in a section of a row does not exceed the maximum of 30. The student uses the formula to construct the table showing the seating capacity for a section in each of the eight rows of the theater.

But some of the work here could use revision. It should be explicitly noted that the number of seats, s(r), needs to be an integer and that non-integer values need to be rounded down. The word "equation" is used in two places where "formula" would have been more standard. Also, the form in which the formula was given is not correct according to the order of operations convention. It should have grouped the first two terms as follows:

$$(2\pi r-12) \div 0.6 \div 6 =$$

# of seats in a row for each section.

And in a more standard usage this formula would have been written with a fraction bar:

$$\frac{2\pi r-12}{(0.6)(6)}$$

Actually, this student never mentioned the term "function" and did not use some features of functions that would have been helpful. A response that illustrated Standard 3 more comprehensively would have done things such as the following:

The formula for the number of seats in a section is a linear function in a variable r.

# of seats in a row section =

$$s(r) = \frac{2\pi r-12}{(0.6)(6)} = \frac{2\pi}{(0.6)(6)}r - \frac{10}{3} \approx 1.75r-3.3.$$

(The various parts of this function are described in the student work.) The last form, $s(r) \approx 1.75r-3.3$, shows that the slope of the function is about 1.75. The *units* of the slope are *seats per meter.* This follows since the number 0.6 has the units *meters per seat.*

Since the slope is 1.75 seats per meter, for every increase in radius of 1.5 meters (the distance between rows in this student's design), there is an increase of about 2.6 seats:

$$1.75 \frac{\text{seats}}{\text{meter}} \cdot 1.5 \text{ meters} \approx 2.6 \text{ seats.}$$

This shows that, moving out from the center, each additional row can get 2.6 more seats per section. But clearly, the number of seats added must be a whole number. This suggests that the 1.5 meter figure for the space between rows could be decreased in a way that allows for an increase of exactly 2 seats for each additional row. Since $(2)/(1.75) \approx 1.15$, we could allow 1.15 meters (instead of 1.5 meters) between rows. This is still greater than the 0.9 meter minimum specified. In the total 12 meter space allowed for rows there could be $12/(1.15) \approx 10.4$ rows. Rounding this down we see that a total of 10 rows would work. Each section of a row would have exactly two more seats than the section of the row in front of it.

A response along these lines would have led to a much more thorough, flexible, and useful analysis of the situation.

Extension

The crucial formula derived by the student for the number of seats in a row of a section given the radius r of the row is:

$$\left\lfloor \frac{2\pi r - (6)(2)}{(0.6)(6)} \right\rfloor$$

(The "lower bracket" notation, $\lfloor s(r) \rfloor$ stands for "the greatest integer less than or equal to s(r)".) An extension could ask the student to generalize this formula in two main ways. First, general parameters could be used for the number of aisles (#) and the width of aisles (W) and seats (w) so that the same formula could be used for different conditions:

number of seats in a section of a row with radius r is:

$$\left\lfloor \frac{2\pi r - \#\,W}{w\,\#} \right\rfloor \quad \frac{\text{total circumference–width of 6 aisles at 2 m}}{\text{(width per seat) (number of sections)}}$$

The requirement is that this must be less than or equal to 30 for all values of r and the parameters.

Another generalization would be to ask the students to express in one formula the number of seats in the whole theater. This would require summing for all the values of r from the smallest to the largest, where r increases each time by the constant separation between rows. This could be done using summation of an arithmetic series. Such work would provide further evidence for parts of Function and Algebra Concepts.

French students preparing for the Baccalauréat Professionnel are expected to study number and algebra concepts in the following way: "In relation to all of the main categories of study, numerical activities will be conducted, as is appropriate in each case, by different methods: mental computation, written computation, with calculators, or with computers. For numerical equations and inequalities, it is not enough to know solution techniques; the student must also learn how to put various problem situations into equations and how to interpret results."

Baccalauréat Professionnel: Enseignements généraux, p. 32.

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Work Sample & Commentary: *Designing a Theater continued*

1 Reading	2 Writing	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech Tools & Techniques	4 Learning & Self-mgmt Tools & Techniques	5 Tools & Techniques for Working With Others

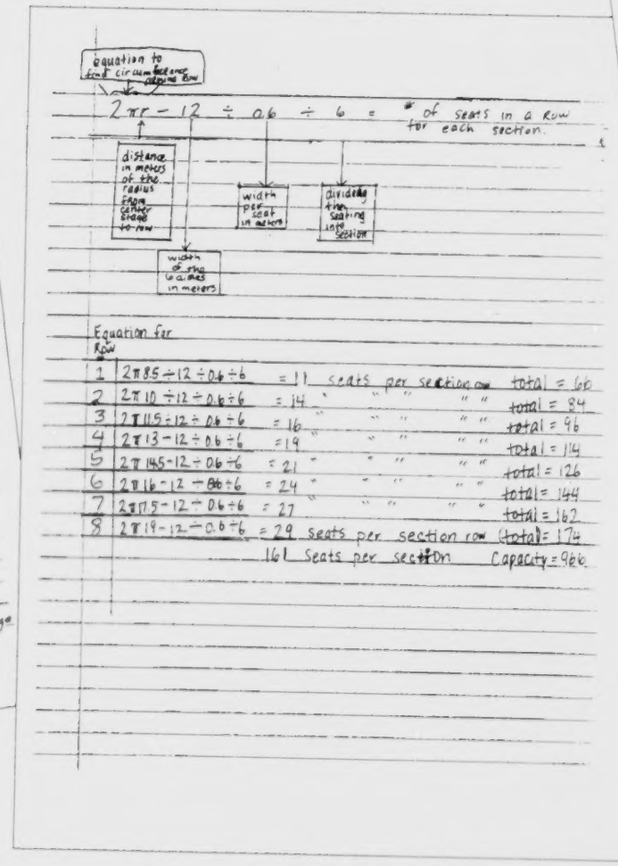
Applied Learning

Calculations:

First we used a diagram of a large circle having a diameter of 42 meters. next from the center we drew a multi-circle making up the stage having a diameter of 10 meters. we then drew six concentric circles equally around the stage and the other around the inside of the perimeter of the Theater both having a width of .2 meters. next we calculated the amount of space between the two (2) concentric circles which was 12 meters. we then decided that width by 1.6 m. where represents 1½ meters per each row, we came up with 8 rows. after deciding on 8 rows we divided the rows into parts. starting we from (4) parts, we increased it to 6 parts, representing the radial aisles having 2 meters wide. We then took a radius of 16" from the center of the stage. (the radius of a 10m diameter stage = 5m + 2m the width of concentric circles within the stage) with 7, we added 1.5 meters, representing the seating space. coming up with 8.5 on from center stage (that was the Radius) etc.

Equation to find # of seats in each row of sections: → $2\pi r - 12 \div .06 \div 6$

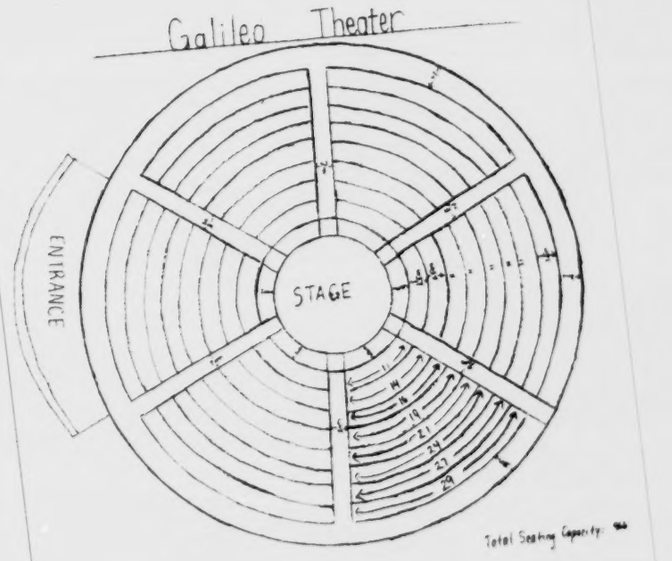
Next page


equation to find circumference
$2\pi r - 12 \div .06 \div 6 =$ # of seats in a row for each section.
distance in meters of the radius from center stage to row
width per seat in meters
dividing the seating into sections
width of the aisles in meters

Equation for Row

1	$2\pi 85 \div 12 \div .06 \div 6$	= 11 seats per section	row total = 66
2	$2\pi 10 \div 12 \div .06 \div 6$	= 14 " " "	" total = 84
3	$2\pi 115 \div 12 \div .06 \div 6$	= 16 " " "	" total = 96
4	$2\pi 13 - 12 \div .06 \div 6$	= 19 " " "	" total = 114
5	$2\pi 145 - 12 \div .06 \div 6$	= 21 " " "	" total = 126
6	$2\pi 16 - 12 \div .06 \div 6$	= 24 " " "	" total = 144
7	$2\pi 175 - 12 \div .06 \div 6$	= 27 " " "	" total = 162
8	$2\pi 19 - 12 \div .06 \div 6$	= 29 " " "	" total = 174

161 Seats per section Capacity = 966



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Samples of student work that help explain "how good is good enough" for these standards can be found immediately following these pages.

To see how these performance descriptions compare with the expectations for elementary school and middle school, turn to pages 110–117.

1. Physical Sciences Concepts

The student understands:

- **structure and properties of matter, in particular, composition of atoms, bonding, elements and compounds;**
- **chemical reactions, including concentration, pressure, temperature, catalysts;**
- **forces and motions, including net force, gravitational, electrical, magnetic;**
- **conservation of energy, in particular, transfer, heat;**
- **interactions of energy and matter, especially waves and wavelengths.**

Examples of performances that may demonstrate understanding include:

- explaining why a local urban area has smog and what can be done about it;
- explaining how an understanding of acceleration and velocity can make one a better driver;
- tracing the transformations of energy from electricity in a CD player or boom box to a sound that can be heard as music;
- explaining the difference between temperature and heat;
- comparing the efficiency and energy consumption of several different methods that could be used locally for generating electricity;
- earning the Energy Merit Badge (Boy Scouts of America) and explaining how it helped you to understand a physical sciences concept.

2. Life Sciences Concepts

The student understands:

- **cells, including structure and function, uses of energy and food;**
- **molecular basis of heredity, including DNA, chromosomes, mutations;**
- **behavior of organisms, especially hormones, nervous system, evolution;**
- **interdependence of organisms, especially flow of energy, cooperation and competition, environmental constraints;**
- **biological evolution, in particular, natural selection; and adaptation, including species, variation, extinction.**

Examples of performances that may demonstrate understanding include:

- predicting how long a plant will live planted in moist soil in a closed glass jar located by a window; telling what additional information would be needed to make a better prediction *(see the National Research Council draft);*
- explaining the chain of inference in DNA testing and supporting a position on whether to include DNA testing as evidence in a capital trial;
- tracing a candy bar from the time it is purchased to the time it is completely expended;
- debating the reasons for the extinction of dinosaurs;
- explaining the prevalence of dark forms of moths 150 years ago and the more recent return to light forms;
- earning the Ecology Merit Badge (Girl Scouts of America) or the Environmental Science Merit Badge (Boy Scouts of America) and explaining how it helped you to understand a life sciences concept.

3. Earth and Space Sciences Concepts

The student understands:

- **Earth's systems, including the Sun, radioactive decay, gravitational energy; weather and climate;**
- **origin and evolution of the Earth system, in particular, estimating geologic time, age of life forms;**
- **forces that shape the Earth; that is, processes and observable results;**
- **natural resource management.**

Examples of performances that may demonstrate understanding include:

- providing an orientation to the climate of the local region to a newcomer; explaining today's weather in that context;
- explaining why people can jump higher on the Moon than they can on Earth;
- explaining the relationship between gravity and energy;
- analyzing the risk of natural disasters in the local region and making recommendations for actions that can be taken to mitigate the damage;
- conducting a study of the geology of an area near the school; describing the likely history of the region, using observations and reference materials.

4. Scientific Connections and Applications

The student understands:

- **big ideas and unifying concepts; for example, order and organization, models, systems, evolution and equilibrium, form and function, cause and effect, constancy and change;**
- **technology, including cost/benefit, constraints, feedback, risk;**
- **the designed world, including agriculture and industry;**
- **health, especially nutrition, exercise, and disease; toxic substances; safety; relationship to environment;**
- **historical and contemporary impact of science.**

Examples of performances that may demonstrate understanding include:

- comparing the form and function of a robot and a human hand;
- arguing for a systemic solution to an environmental problem that concerns the school community;
- proposing modifications to improve roller blades, skateboards, bicycles, or similar objects to make them safer, faster, or less expensive;
- conducting a study of the school cafeteria, including food storage and preparation, nutritional value, and student preferences; making recommendations for improvement;
- considering the positive and negative consequences of a technological innovation that has occurred in your lifetime.

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5. Scientific Thinking

The student uses scientific reasoning strategies, scientific knowledge, and common sense to formulate questions about, understand, and explain a wide range of phenomena; that is, the student:

- **frames questions so that causes and effects can be distinguished; identifies variables that influence a situation and can be controlled;**
- **formulates and revises explanations and models based on evidence and logical argument, preserving significant information;**
- **proposes, recognizes, analyzes, considers, and critiques alternative explanations; distinguishes between fact and opinion;**
- **identifies problems or design opportunities; proposes designs and chooses among alternatives; implements a solution and evaluates its consequences;**
- **works individually and in teams to collect and share information and ideas.**

Examples of scientific thinking include:

- predicting how long a plant will live planted in moist soil in a closed glass jar located by a window; telling what additional information would be needed to make a better prediction *(see the National Research Council draft);*
- determining if evidence in the summary data chart in Consumer Reports substantiates recommendations about the "Best Buy" for something you want to purchase;
- explaining the chain of inference in DNA testing and supporting a position on whether to include DNA testing as evidence in a capital trial;
- explaining lines of evidence for theories of dinosaur extinction.

6. Scientific Tools and Technologies

The student uses tools and technologies to collect and analyze data; that is, the student:

- **uses a variety of traditional and electronic tools to directly, indirectly, and remotely observe and measure objects, organisms, and phenomena, being alert to accuracy and precision;**
- **records and stores data in a variety of formats, including databases, audiotapes and videotapes;**
- **analyzes data, taking steps to limit observer and sample biases, using concepts and skills from Mathematics Standard 4, Statistics and Probability Concepts;**
- **acquires information from print, electronic, and visual sources, including the Internet.**

Examples of using scientific tools and technologies include:

- using a remote sensor to gather data on something that you cannot see;
- evaluating the accuracy and timeliness of information from the Weather Channel;
- using the Internet to obtain current information on a rapidly changing scientific topic;
- using a computer interface to measure the velocity of objects;
- using telecommunications to compare data on similar investigations with students in another state;
- earning the Orienteering Merit Badge (Boy Scouts of America) and teaching another student what to do when he or she gets lost.

7. Scientific Communication

The student communicates clearly and effectively about the natural world; that is, the student:

- **represents data and results in multiple ways; for example, numbers and statistics; drawings, diagrams, and pictures; sentences; charts and tables; models; and uses the most effective way to make the point;**
- **summarizes varied sources of evidence, including his or her own data and published reports;**
- **critiques published materials, including popular and academic sources;**
- **explains a scientific concept or procedure to other students;**
- **communicates in a form suited to the purpose and the audience; responds to critical comments with data and reasoning.**

Examples of scientific communication include:

- making recommendations to community officials about water quality on and near the campus;
- critiquing a *Time* magazine article which reports on something you have studied;
- writing an advertisement for a cold relief product that explains how it works;
- analyzing a ballot initiative on toxic chemicals;
- evaluating the accuracy and timeliness of information from the Weather Channel;
- writing a review of a Nova program;
- earning the Model Design and Building Merit Badge (Boy Scouts of America) and explaining what constitutes an effective model.

8. Scientific Investigation

The student completes projects drawn from the following types of investigation, including at least one full investigation each year and, over the course of high school, investigations representing all four types.

- **Controlled experiment;**
- **Fieldwork;**
- **Design;**
- **Secondary research; that is, use of others' data.**

A single project may draw on more than one type of investigation.

A full investigation includes:

- **questions that can be studied using the resources available;**
- **procedures that are safe, humane, and ethical; respect privacy and property rights;**
- **data that have been collected and recorded *(see also Science Standard 6)* in ways that others can verify, and analyzed using skills expected at this grade level *(see also Mathematics Standard 4);***
- **data and results that have been represented *(see also Science Standard 7)* in ways that fit the context;**
- **recommendations, decisions, and conclusions based on evidence;**
- **acknowledgment of references and contributions of others;**
- **results that are communicated appropriately to audiences;**
- **reflection and defense of conclusions and recommendations from other sources and peer review.**

Examples of scientific investigations include:

- investigating how the incidence of asthma is related to weather;
- investigating whether different sports shoes are better designed for their respective sports;
- conducting a study of the geology of an area near the school; describing the likely history of the region, using observations and reference materials;
- studying the distribution of a species in the region or state and determining if it is endangered;
- investigating whether the shape of a speaker-cabinet affects sound quality.

The Science standards are founded upon both the American Association for the Advancement of Science's Project 2061 *Benchmarks for Scientific Literacy* and the National Research Council's *National Science Education Standards draft.* The Science standards will also take into account the work of the National Science Teachers Association as they revise their *Scope, Sequence, and Coordination Content Core* and develop assessment tasks.

These documents, each of which runs to several hundred pages, contain detail that amplifies the meaning of the terms used here.

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Work Sample & Commentary: *The Density of Sand*

1 Reading	2 Writing	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech. Tools & Techniques	4 Learning & Self-mgmt Tools & Techniques	5 Tools & Techniques for Working With Others

Applied Learning

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 56–57.

Science required by the task

This work was an entry in a Golden State Examination Science Portfolio for the category "Problem-solving Investigation." Since it was a portfolio entry, it was expected that revision would take place after feedback from peers and the teacher. Students were expected to work on the investigation in small groups and to write up their reports individually. Students were required to submit a piece of work and an entry slip ("Self-reflection Sheet") on which they answered questions about the concept that they investigated and the role that they played in the investigation.

These examinations are given in Biology, Chemistry, and Integrated Science, so the task requires the student to demonstrate evidence of understanding in Standard 1, Physical Sciences Concepts and/or Standard 2, Life Sciences Concepts. The expectations for the investigation require that students provide evidence related to Standard 5, Scientific Thinking and Standard 6, Scientific Tools and Technologies.

Science evident in this student response

In this entry, a pair of students were asked to devise and carry out a method for determining the density of sand with air around the sand granules and the density of sand alone. Because they were investigating density, they were required to demonstrate understanding of parts of the following Science standards:

Standard 1, Physical Sciences Concepts—structure and properties of matter;

Standard 5, Scientific Thinking;

Standard 6, Scientific Tools and Technologies.

Physical Sciences Concepts

The work shows clear evidence for understanding the concept of density, e.g., "The equation for density is mass divided by volume." The inverse relationship that exists between density and volume is given in the statement, "Since the volume of the sand [with] air was larger, it had a lower density." This flexibility with a ratio concept of density would not be expected at the middle school level, where an understanding of the concept in concrete, physical terms is expected. The high school level understanding is further evident in the statement, "Since density is an intensive property, the difference in sample sizes among the other groups should not have affected the results." And the discussion of the real world applications of this understanding (see item #3 on the Self-reflection Sheet) shows that the student can generalize the situation from the immediate context.

Scientific Thinking
Scientific Tools and Technologies

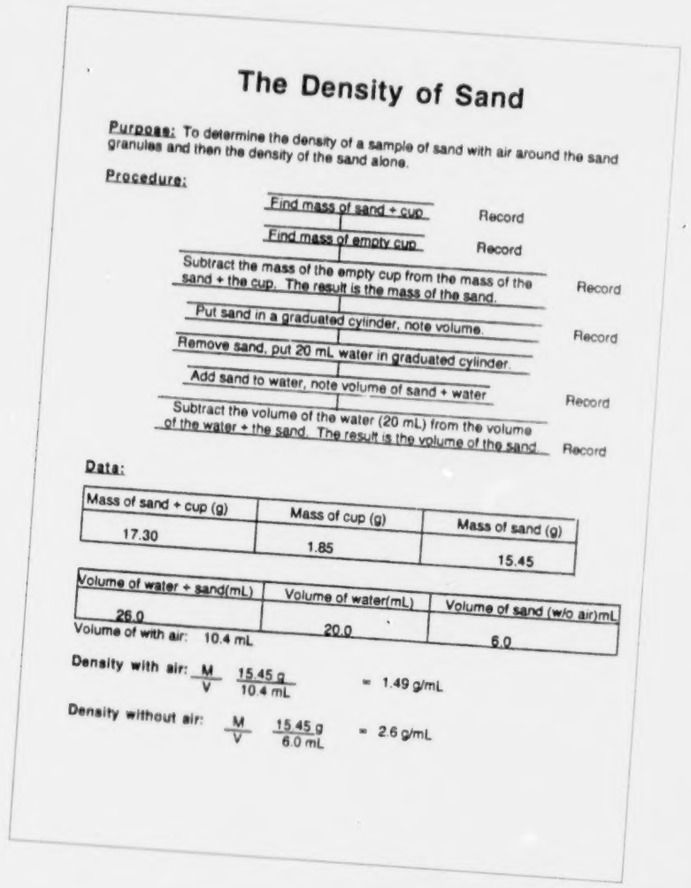
The assignment required that the students develop an appropriate procedure. Water displacement is a technique routinely used to measure the volume of irregular solids. Generalizing from the standard use to the one in this experiment is a strong feature of both experimental design (Scientific Thinking) and measurement (Scientific Tools and Technologies). Other aspects of Scientific Thinking are straightforward.

There is a clear attention to accuracy and precision throughout the work, e.g., "we devised a more accurate plan of weighing the sand within the cup…." The use of the graduated cylinder for the dry sand and then the use of the same equipment for the water displacement method shows attention to accuracy as well.

The comparison of one group to four others was further evidence of the check for accuracy tied to Scientific Tools and Technologies. Three of the five groups had results which were similar (density with air 1.49, 1.4, and 1.49; density without air 2.6, 2.5, and 2.73). However, the explanation, "three out of four groups we compared results with had answers similar to our own," does not correspond to the data on the second page. It is likely that the data for Group #3 are reversed. This is supported when the further analysis explains that "other groups" might have made errors in measurement or procedures. The suggestion of all groups double checking their measurements and calculations is consistent with the quality of work required by Scientific Tools and Technologies.

Going beyond

This work shows evidence for part of the standard for Physical Sciences Concepts but would need to be accompanied by work of similar quality with chemical reactions, forces and motion, and energy to meet the standard. Similarly, additional work would be needed to meet the standards for Scientific Thinking and Scientific Tools and Technologies, in particular, alternative explanations and multiple data sources.



The Density of Sand

Purpose: To determine the density of a sample of sand with air around the sand granules and then the density of the sand alone.

Procedure:

Find mass of sand + cup	Record
Find mass of empty cup	Record
Subtract the mass of the empty cup from the mass of the sand + the cup. The result is the mass of the sand.	Record
Put sand in a graduated cylinder, note volume.	Record
Remove sand, put 20 mL water in graduated cylinder.	
Add sand to water, note volume of sand + water	Record
Subtract the volume of the water (20 mL) from the volume of the water + the sand. The result is the volume of the sand.	Record

Data:

Mass of sand + cup (g)	Mass of cup (g)	Mass of sand (g)
17.30	1.85	15.45

Volume of water + sand(mL)	Volume of water(mL)	Volume of sand (w/o air)mL
26.0	20.0	6.0

Volume of with air: 10.4 mL

Density with air: $\frac{M}{V}$ $\frac{15.45\ g}{10.4\ mL}$ = 1.49 g/mL

Density without air: $\frac{M}{V}$ $\frac{15.45\ g}{6.0\ mL}$ = 2.6 g/mL

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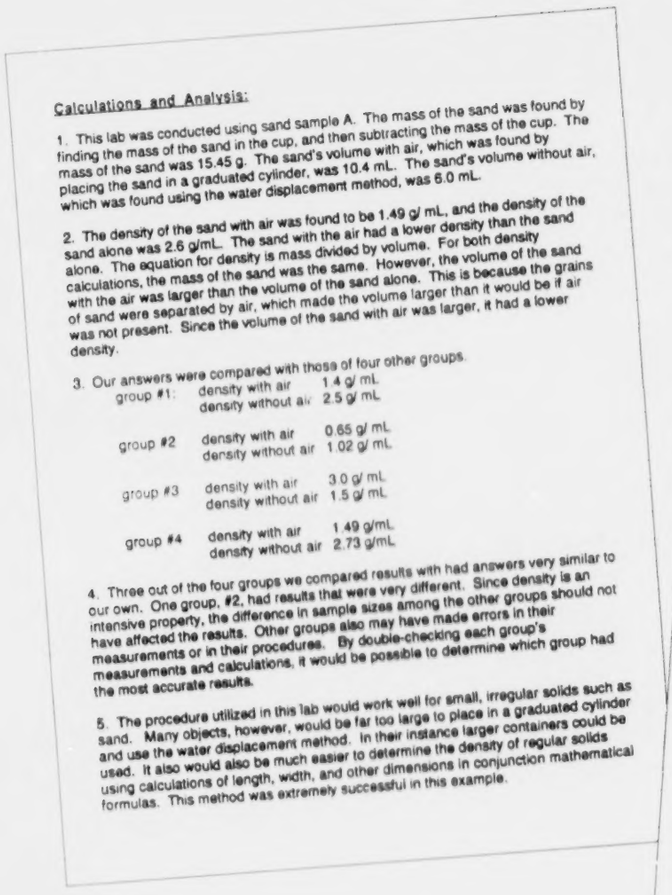


Calculations and Analysis:

1. This lab was conducted using sand sample A. The mass of the sand was found by finding the mass of the sand in the cup, and then subtracting the mass of the cup. The mass of the sand was 15.45 g. The sand's volume with air, which was found by placing the sand in a graduated cylinder, was 10.4 mL. The sand's volume without air, which was found using the water displacement method, was 6.0 mL.

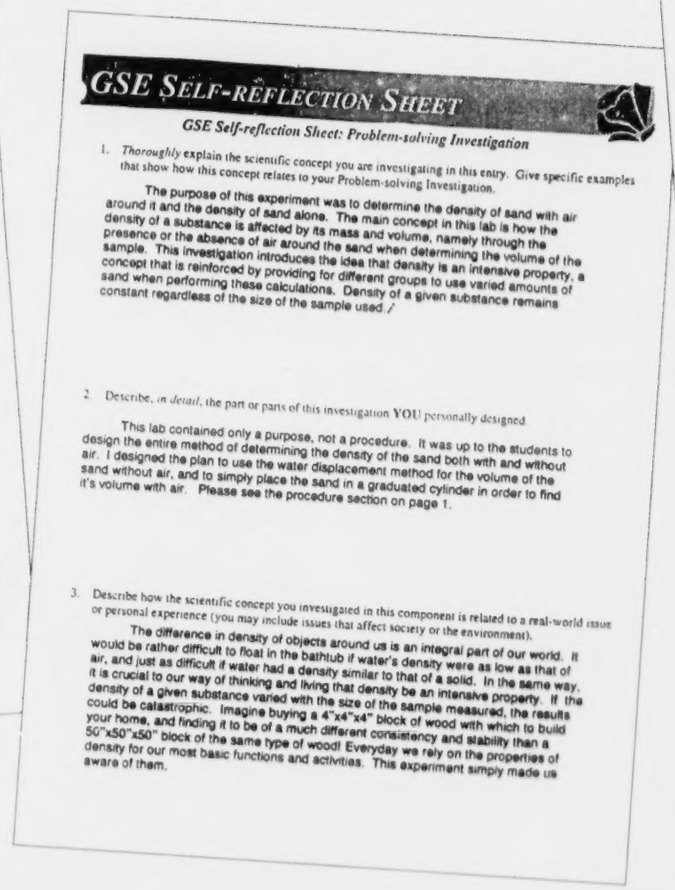
2. The density of the sand with air was found to be 1.49 g/ mL, and the density of the sand alone was 2.6 g/mL. The sand with the air had a lower density than the sand alone. The equation for density is mass divided by volume. For both density calculations, the mass of the sand was the same. However, the volume of the sand with the air was larger than the volume of the sand alone. This is because the grains of sand were separated by air, which made the volume larger than it would be if air was not present. Since the volume of the sand with air was larger, it had a lower density.

3. Our answers were compared with those of four other groups.

group #1:	density with air	1.4 g/ mL
	density without air	2.5 g/ mL
group #2	density with air	0.65 g/ mL
	density without air	1.02 g/ mL
group #3	density with air	3.0 g/ mL
	density without air	1.5 g/ mL
group #4	density with air	1.49 g/mL
	density without air	2.73 g/mL

4. Three out of the four groups we compared results with had answers very similar to our own. One group, #2, had results that were very different. Since density is an intensive property, the difference in sample sizes among the other groups should not have affected the results. Other groups also may have made errors in their measurements or in their procedures. By double-checking each group's measurements and calculations, it would be possible to determine which group had the most accurate results.

5. The procedure utilized in this lab would work well for small, irregular solids such as sand. Many objects, however, would be far too large to place in a graduated cylinder and use the water displacement method. In their instance larger containers could be used. It also would also be much easier to determine the density of regular solids using calculations of length, width, and other dimensions in conjunction mathematical formulas. This method was extremely successful in this example.



GSE SELF-REFLECTION SHEET

GSE Self-reflection Sheet: Problem-solving Investigation

1. *Thoroughly* explain the scientific concept you are investigating in this entry. Give specific examples that show how this concept relates to your Problem-solving Investigation.

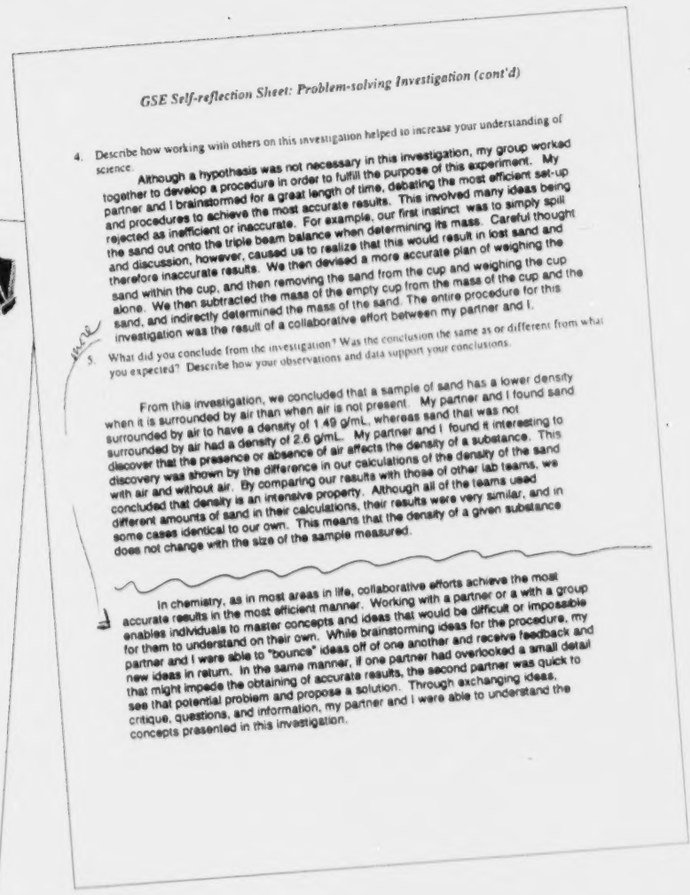
The purpose of this experiment was to determine the density of sand with air around it and the density of sand alone. The main concept in this lab is how the density of a substance is affected by its mass and volume, namely through the presence or the absence of air around the sand when determining the volume of the sample. This investigation introduces the idea that density is an intensive property, a concept that is reinforced by providing for different groups to use varied amounts of sand when performing these calculations. Density of a given substance remains constant regardless of the size of the sample used./

2. Describe, *in detail*, the part or parts of this investigation YOU personally designed.

This lab contained only a purpose, not a procedure. It was up to the students to design the entire method of determining the density of the sand both with and without air. I designed the plan to use the water displacement method for the volume of the sand without air, and to simply place the sand in a graduated cylinder in order to find it's volume with air. Please see the procedure section on page 1.

3. Describe how the scientific concept you investigated in this component is related to a real-world issue or personal experience (you may include issues that affect society or the environment).

The difference in density of objects around us is an integral part of our world. It would be rather difficult to float in the bathtub if water's density were as low as that of air, and just as difficult if water had a density similar to that of a solid. In the same way, it is crucial to our way of thinking and living that density be an intensive property. If the density of a given substance varied with the size of the sample measured, the results could be catastrophic. Imagine buying a 4"x4"x4" block of wood with which to build your home, and finding it to be of a much different consistency and stability than a 50"x50"x50" block of the same type of wood! Everyday we rely on the properties of density for our most basic functions and activities. This experiment simply made us aware of them.



GSE Self-reflection Sheet: Problem-solving Investigation (cont'd)

4. Describe how working with others on this investigation helped to increase your understanding of science.

Although a hypothesis was not necessary in this investigation, my group worked together to develop a procedure in order to fulfill the purpose of this experiment. My partner and I brainstormed for a great length of time, debating the most efficient set-up and procedures to achieve the most accurate results. This involved many ideas being rejected as inefficient or inaccurate. For example, our first instinct was to simply spill the sand out onto the triple beam balance when determining its mass. Careful thought and discussion, however, caused us to realize that this would result in lost sand and therefore inaccurate results. We then devised a more accurate plan of weighing the sand within the cup, and then removing the sand from the cup and weighing the cup alone. We then subtracted the mass of the empty cup from the mass of the cup and the sand, and indirectly determined the mass of the sand. The entire procedure for this investigation was the result of a collaborative effort between my partner and I.

5. What did you conclude from the investigation? Was the conclusion the same as or different from what you expected? Describe how your observations and data support your conclusions.

From this investigation, we concluded that a sample of sand has a lower density when it is surrounded by air than when air is not present. My partner and I found sand surrounded by air to have a density of 1.49 g/mL, whereas sand that was not surrounded by air had a density of 2.6 g/mL. My partner and I found it interesting to discover that the presence or absence of air affects the density of a substance. This discovery was shown by the difference in our calculations of the density of the sand with air and without air. By comparing our results with those of other lab teams, we concluded that density is an intensive property. Although all of the teams used different amounts of sand in their calculations, their results were very similar, and in some cases identical to our own. This means that the density of a given substance does not change with the size of the sample measured.

In chemistry, as in most areas in life, collaborative efforts achieve the most accurate results in the most efficient manner. Working with a partner or a with a group enables individuals to master concepts and ideas that would be difficult or impossible for them to understand on their own. While brainstorming ideas for the procedure, my partner and I were able to "bounce" ideas off of one another and receive feedback and new ideas in return. In the same manner, if one partner had overlooked a small detail that might impede the obtaining of accurate results, the second partner was quick to see that potential problem and propose a solution. Through exchanging ideas, critique, questions, and information, my partner and I were able to understand the concepts presented in this investigation.

In New Zealand, secondary school students are expected to "Develop Investigative Skills and Attitudes" in the sciences. Students at this level are expected to be able to "ask a series of related questions of themselves, their group, and resource people and refine questions to make them suitable for scientific investigation; integrate their scientific ideas and personal observations with the scientific ideas of others to make testable predictions or to identify possible solutions for trialling; design 'fair tests,' simple experiments, trails, and surveys, with clear specification and control of likely variables."

Science in the New Zealand Curriculum, p. 44.

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Work Sample & Commentary: *Photosynthesis Lab*

1 Reading	2 Writing	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

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Applied Learning

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Science required by the task

This work was an entry in a Golden State Examination Science Portfolio for the category "Problem-solving Investigation." Since it was a portfolio entry, it was expected that revision would take place after feedback from peers and the teacher. Students were expected to work on the investigation in small groups and to write up their reports individually. Students were required to submit a piece of work and an entry slip ("Self-reflection Sheet") on which they answered questions about the concept that they investigated and the role that they played in the investigation.

These examinations are given in Biology, Chemistry, and Integrated Science, so the task requires the student to demonstrate evidence of understanding in Standard 1, Physical Sciences Concepts and/or Standard 2, Life Sciences Concepts. The expectations for the investigation require that students provide evidence related to Standard 5, Scientific Thinking and Standard 6, Scientific Tools and Technologies.

Science evident in this student response

In this entry, a group of students investigated photosynthesis, the process by which plants produce food. In the presence of light and chlorophyll, the plant uses carbon dioxide and water to produce sugar and oxygen. These students decided to investigate the rate of photosynthesis in the presence of different wavelengths of light by varying the color of light and keeping track of the production of oxygen. This investigation required that the students provide evidence related to parts of the following Science standards:

Standard 1, Physical Sciences Concepts—chemical reactions and interactions of energy and matter;

Standard 2, Life Sciences Concepts—cells, structure and function, uses of energy;

Standard 5, Scientific Thinking;

Standard 6, Scientific Tools and Technologies.

Physical Sciences Concepts

Two distinct aspects of physical sciences concepts are illustrated in this work: chemical reactions and interactions of energy and matter. The explanation of the chemical reaction, photosynthesis, is quite clear. For example, on the page headed "Conclusion," in the second paragraph of the draft, see the final sentence, "the more oxygen, the faster the rate of photosynthesis of the plant because more H_2O is being split to O_2 in the light reaction." The explanation is also sophisticated. For example, the final sentence of the third paragraph states: "The electrons of this reaction come from the oxygen of H_2O." Such explanations provide evidence of deep understanding and also touch on a third part of the standard for Physical Sciences Concepts—structure and properties of matter (bonding).

The discussion that follows the cell diagram provides evidence for understanding interactions of matter and energy, specifically wavelengths of light. For example: "This is why the white light had the fastest rate of photosynthesis. White light contains the whole visible color spectrum." In the last paragraph of the Self-reflection Sheet, the student observes that green light is reflected by the plant and will therefore be less effective in providing the energy for photosynthesis. Note that the word "refracted" is used interchangeably with "reflected." The usual mistake, that green objects absorb green light, is not evident here, so this is not viewed as evidence of misunderstanding.

An alternative or additional explanation for the high rate of photosynthesis for the white light is that all of the colored filters reduced the intensity of the light, meaning that fewer photons reached the leaf. There is no mention of the intensity of the light, but from the description of the procedure it is likely that this variable was not controlled.

Life Sciences Concepts

The work presents a description of what is going on inside the chloroplasts of the plant, showing an understanding of the structure and functions of the cell. The energy exchanges taking place at the cellular level are in the illustration of the student's working draft and in the conceptual information given in the conclusion. The explanation of the flow of energy offers evidence for conceptualization of the dynamics of the process whereby plants produce food and depend on outside factors for that process. On the Self-reflection Sheet, the statement "Now, we all know that the plant is not really trying to produce oxygen, but is producing glucose…oxygen just happened to be a waste product…" is strong evidence for conceptualization of the process of photosynthesis.

The phrase "energy rich ATP and NADPH" appears twice in the paragraph above the cell drawing. The notes accompanying the illustration say that "NADPH and ATP are high energy." It is true that NADPH has reducing power, but it is not an energy source, although ATP is.

Scientific Thinking

The techniques employed in this investigation are appropriate to the questions this work attempts to answer. The work certainly shows the use of concepts to aid in the investigation. A thorough understanding of photosynthesis is used both to design the experiment and to frame the discussion of the results.

Scientific Tools and Technologies

The procedures are well explained. This provides evidence for part of Scientific Tools and Technologies —records and stores data in a variety of formats. The variables of time, size of the elodea sample, and amount of sodium carbonate were all controlled. While the light source seems to have been the same throughout the experiment, covering it with filters reduced its intensity so that this variable was not controlled. With this notable omission, the conclusions are based on the results from the experiment and well defended.

Going beyond

At the end of the Self-reflection Sheet, the student says, "The results we saw was [sic] mostly what we expected…before starting the lab." It is evident that the students knew so much about photosynthesis before they started that they were conducting the investigation to confirm what they thought would happen. This kind of confirmatory investigation is a valuable experience. It allows students to demonstrate that what they already know is useful in predicting the outcome of new experiments, but it serves mainly to evidence for conceptual understanding, scientific thinking, and the use of scientific tools and technologies. Because the students found what they expected to find, they did not think about alternative explanations, such as light intensity. Therefore, they did not challenge their interpretation of the results.

This work is a strong start on meeting the requirements of Standard 8, Scientific Investigation, but an investigation of a question for which the students could not predict the results before starting would provide better evidence of their ability to use an investigation to find out something they did not already know.

To meet the standard for Physical Sciences Concepts, this work would need to be accompanied by work of comparable quality demonstrating understanding of force and motion; to meet the standard for Life Sciences Concepts, this work would need to be accompanied by work of comparable quality at the level of organisms; to meet the standards for Scientific Thinking and Scientific Tools and Technologies, this work would need to be accompanied by work that showed alternative explanations and multiple data sources.

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Photosynthesis Lab

PHOTOSYNTHESIS LAB

Introduction:

Photosynthesis is an important process that is carried out within the chloroplast of plants. This reaction uses 6 CO_2 and the electrons from six water molecules (6 H_2O) to make glucose ($C_6H_{12}O_6$) and free oxygen (O_2), which will be explained in the conclusion. This reaction is powered by light, as the name implies (photo means light). The purpose of this lab is to discover how different wavelengths of visible light; red, orange, blue, and so on affect the process of photosynthesis. My hypothesis is that the water plant elodea will produce the lowest rate of photosynthesis when exposed to the green light, the highest with full spectrum white light, (because we see that green light is reflected by the plant and not absorbed by the plant) with the other wavelengths somewhere in between.

Procedures:

The elodea plants will be placed in a solution of sodium carbonate in a test tube. An identical test tube of sodium carbonate without any plant material will be used to demonstrate that the sodium carbonate alone produces no reaction when exposed to the various wavelengths of light.

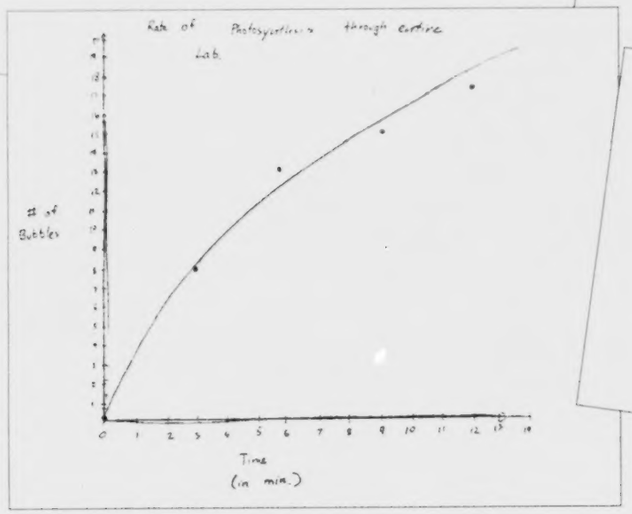
1. Place a 5 cm length of elodea in a test tube, then carefully add 10 ml of sodium carbonate, making sure that no bubbles form around the plant. If bubbles do appear, gently flick the tube until they disappear. Place the test tube in the test tube rack.
2. Prepare a second tube of 10 ml of sodium carbonate, leaving the plant out, and place it in the test tube rack next to the first tube.
3. Shine a full spectrum white light on the two tubes for 3 minutes, and count the number of bubbles which float to the surface. Record your results in the data table below.
4. Repeat the experiment, using colored cellophane over the white light source until all of the colors of cellophane have been tested and recorded.

Results:

During the test we saw bubbles form on the elodes leaves and counted many more bubbles that actually broke free from the leaves and floated to the surface of the sodium carbonate solution. The bubbles were produced the fastest when the white light was shining on the plant. No bubbles were produced in any of the plain sodium carbonate tubes.

Color of Light	# of bubbles over 3 min.
White	8
Red	5
Green	2
Yellow	3
Blue	2

Rate of Photosynthesis



Conclusion:

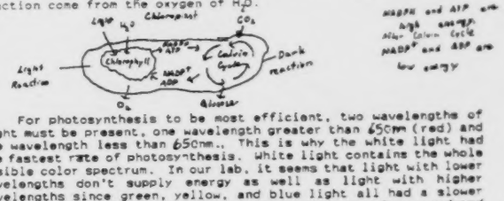
We expected the green light to produce the least or no bubbles from the stem. Our hypothesis was partially correct. The tubes exposed to the green and blue light each gave off only two bubble.. The tube exposed to the yellow light gave off 3 bubbles, red light gave off 5, and the white light gave off 8 bubbles.

The concept of this lab is photosynthesis. Photosynthesis is the process in which carbon dioxide and water is turned to simple sugars and oxygen. In this reaction, chlorophyll (the catalyst) and light (the energy source) must be present.

$$6\ CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2 + 6\ H_2O$$

(Carbon Dioxide) + (Water) → (Glucose) + (Oxygen) + (water)

In this lab, we soaked the plant stem in water and sodium carbonate. Sodium carbonate provided carbon dioxide within the water, giving the plant the materials needed for photosynthesis to occur. Photosynthesis occurs in two basic reactions, light and dark reactions. The light reaction occurs first, oxidizing water to oxygen, and the dark reaction combines the hydrogen with carbon dioxide to form simple carbohydrates. Oxygen is given off as a waste product, which were what the bubbles we saw coming out of the plant stem were. The more bubbles, the more oxygen is produced from the plant and in turn, the more oxygen, the faster the rate of photosynthesis of the plant because was H_2O is being split to O_2 in the light reaction. Within, the chloroplasts of the plant, there are chlorophyll, which is capable of absorbing light energy and exciting water molecules, oxidizing H_2O to O_2. As water is being oxidized into oxygen, energy rich ATP and NADPH are produced. Then, in the dark reaction, this energy rich ATP and NADPH are used in the Calvin cycle to convert CO_2 to carbohydrates. The electrons of this reaction come from the oxygen of H_2O.



For photosynthesis to be most efficient, two wavelengths of light must be present, one wavelength greater than 650nm (red) and one wavelength less than 650nm.. This is why the white light had the fastest rate of photosynthesis. White light contains the whole visible color spectrum. In our lab, it seems that light with lower wavelengths don't supply energy as well as light with higher wavelengths since green, yellow, and blue light all had a slower rate of photosynthesis. We know this because our plant produced the least oxygen under these light conditions.

All life on earth is dependant on photosynthesis, directly or indirectly. Plants are the bottom of the food chain. They make food for themselves and are food for higher life forms. If all photosynthesis-capable life forms disappear, animals would slowly, one by one would die of starvation. Also plants, during photosynthesis, produce oxygen for oxygen breathing life forms. Animals use oxygen and create carbon dioxide as waste while plants complete the cycle by using carbon dioxide and creating oxygen as waste. Without plants, we would have no oxygen to breath.

Our conclusion is that different wavelengths of light does effect the rate of photosynthesis; generally, the higher the wavelength, the faster the rate of photosynthesis and the lower the wavelength, the slower the rate of photosynthesis. Our background information states that violet would also be an effective wavelength for photosynthesis. Unfortunately, we did not get a chance to test this color.

If there are any errors in conducting the experiment, it may have been in the experimental design. We could have weighed the plants as an additional control. We could have let the tubes stand in the light longer than 3 minutes, but I don't think either of these changes would have significantly changed the results of the experiment.

FURTHER TOPICS OF STUDY

•Does the intensity of the light effect the rate of photosynthesis?

GSE Self-reflection Sheet

1. *Thoroughly explain the scientific concepts you are investigating in this entry. Give specific examples that show how this concept relates to your Problem-solving Investigation.*

Every time we take in a breath of air, we breath in oxygen. This oxygen is not infinite. It comes from plants carrying out photosynthesis, a complicated and beautiful process in which water and carbon dioxide is turned to oxygen and glucose. We breath in the oxygen, a waste product given off from the plants, while the plant uses the glucose. Normally, what powers this process is light from the sun. The purpose of this investigation is to explore how different wavelengths of light, or different power sources, effect the rate of photosynthesis. We investigated this by measuring the output of oxygen under different light sources. The more oxygen is produced, the faster photosynthesis had to run in the plant to produce this oxygen. (More info in Conclusion)

2. Describe, *in detail*, the part or parts of this investigation YOU personally designed.

I thought of what wavelengths of light we should investigate. I made sure that the choices were evenly spread over the color spectrum, to insure that most of the wavelengths of light are tested. I also designed the amount of time we should spend on each test counting bubbles, which was 3 minutes. I had to make sure that the time was long enough to get accurate test results while not so long that precious lab time is wasted.

3. Describe how the scientific concept you investigated in this component is related to a real-world issue or personal experience (you may include issues that affect society or the environment).

Every time we eat something, like hamburgers, hot dogs, spinach, and other foods, we are either directly or indirectly consuming the products of photosynthesis. It's obvious that when we eat plants, we are eating plants that nurtures itself with the glucose produced in photosynthesis. When we eat animals, those animals may have eaten other animals which may have eaten other animals which finally may have eaten the plant. The point is that if photosynthesis ceased to exist, there be no plants, which means there will be no animals because they feed on the non-existing plants and life on earth would just not be possible. Photosynthesis is a process we take for granted.

GSE Self-reflection Sheet: Problem-solving Investigation (cont'd)

4. Describe how working with others on this investigation helped to increase your understanding of science.

Before the lab, every single one of us was confused in their own way. When we got together and started discussing about it, our knowledge started to fill each other's gaps until we had the whole scientific concept of photosynthesis in our minds. Personally, I had no idea why the output of oxygen would tell us the rate of photosynthesis within the plant. I just knew the basic fact that the more oxygen produced, the faster photosynthesis is occurring. Now, we all know that the plant is not really trying to produce oxygen, but is producing glucose to nurture itself and oxygen just happened to be a waste product we need to survive produced while producing the glucose the plants need to survive.

5. What did you conclude from the investigation? Was the conclusion the same as or different from what you expected? Describe how your observations and data support your conclusions.

We concluded that different wavelengths of light do indeed effect the rate of photosynthesis. Our data shows oxygen being given off from the plant faster when red or white light was shined on the plant. We concluded that in the presence of red or white light, photosynthesis was occurring faster because the rate of oxygen being released indicated the speed of photosynthesis. We weren't surprised that white light was so effective because white light, unlike other colors, is not just one wavelength of light, but the whole spectrum of wavelengths of light combined. From the white light, the plant had access of every wavelength of light. We also found that in the presence of green light, the rate oxygen was being released was extremely slow compared to the other wavelengths of light, which means the rate of photosynthesis was also extremely slow. We conclude this is so because green is refracted from the leaves. When green light is shown on the plant, the plant probably reflects it back out instead of absorbs it because we could see the refracted green light. This is why plants are green. The results we saw was mostly what we expected because before starting the lab, we had the chance to get a lot of background information.

In Australia, students are expected to be able to explain "how living things obtain, store and transport nutrients, transform energy and manage wastes. {this is} evident when students, for example, investigate the way green plants use sunlight to produce simple sugars in photosynthesis."

Science—a curriculum profile for Australian schools, p. 88.

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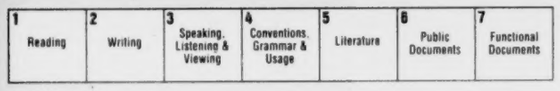
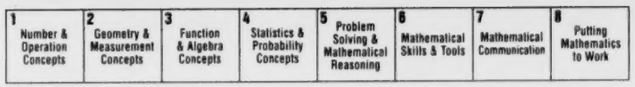
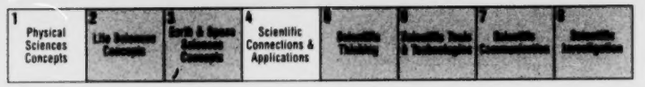
Work Sample & Commentary: *A Geographical Report*



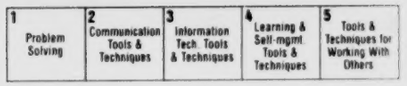
English Language Arts


1 Number & Operation Concepts
2 Geometry & Measurement Concepts
3 Function & Algebra Concepts
4 Statistics & Probability Concepts
5 Problem Solving & Mathematical Reasoning
6 Mathematical Skills & Tools
7 Mathematical Communication
8 Putting Mathematics to Work

Mathematics


1 Physical Sciences Concepts
2 Life Sciences Concepts
3 Earth & Space Sciences Concepts
4 Scientific Connections & Applications
5 Scientific Thinking
6 Scientific Tools & Technologies
7 Scientific Communication
8 Scientific Investigation

Science


1 Problem Solving
2 Communication Tools & Techniques
3 Information Tech. Tools & Techniques
4 Learning & Self-mgmt. Tools & Techniques
5 Tools & Techniques for Working With Others

Applied Learning

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 56–57.

The standards for middle school are set at a level of performance approximately equivalent to the end of eighth grade and for high school at the end of tenth grade. It is expected that some students might achieve these levels earlier and others later than these grades. It is the expected quality of work rather than the age or grade of the student that we are attempting to illustrate. This piece of work is used in the middle school volume to illustrate the quality expected for writing in the English Language Arts standards. The conceptual understanding in Science, however, is at the level expected for the high school standard. Thus, we have included the piece again here despite the age or grade of the student who produced it.

Science required by the task

Students were assigned to write a report for science class using at least five sources, only two of which could be encyclopedias. Clarifications or illustrations of key points were encouraged, as was a complete bibliography. The task therefore required the students to demonstrate most of the components of Standard 7, Scientific Communication.

Science evident in this student response

The report goes well beyond the assignment and provides evidence for the quality of work expected for the following Science standards:

Standard 2, Life Sciences Concepts—interdependence of organisms;

Standard 3, Earth and Space Sciences—Earth system, forces that shape the Earth, and natural resource management;

Standard 5, Scientific Thinking;

Standard 6, Scientific Tools and Technologies;

Standard 7, Scientific Communication;

Standard 8, Scientific Investigation—secondary research and design.

Scientific Investigation

At first glance, this appears to be secondary research in science. However, as the report progresses, questions emerging in the research lead to design work. Both are forms of Scientific Investigation.

For example, the work offers both a complete bibliography and acknowledgment of assistance from experts, although the sources are not cited in the text. The inclusion of a plan for a nature center is a clear illustration of making recommendations, decisions, and conclusions based on evidence. The work leaves a clear path for another student to follow in order to replicate the investigation or verify conclusions.

Peer review is not included in the work. However, the extensive communication with experts shows that the conclusions were informed by informal external review as the report was constructed. The student argues from evidence to draw conclusions and make recommendations in a way that is focused and coherent. This coherence and the reliance upon evidence illustrate the quality of work expected for parts of Scientific Investigation.

Life Sciences Concepts

Several parts of the investigation provide evidence for Life Sciences Concepts—interdependence of organisms. The investigation was framed around what vernal pools are and "how they are a sensitive natural habitat" [p. 1]. It shows a thorough understanding of this particular habitat. Evidence of the comprehension of ecosystems is provided in discussions of changes in resources and energy flow. The idea of plants and animals adapting to changing environments, evolutionary changes, and species diversity and interdependence are all included in one succinct paragraph [p. 6, par. 4]. The compelling and authoritative voice of the work shows an understanding of how this wetland works biologically.

Earth and Space Sciences Concepts

This work also provides evidence for parts of Earth and Space Sciences—Earth's systems…weather and climate; forces that shape the Earth; and natural resource management. An understanding of Earth systems (weather and climate) is illustrated in the diagram on page six. Understanding of forces that shape the Earth is illustrated in the text and drawing on page three. Natural resource management is illustrated throughout the piece, particularly at the top of page six.

Scientific Thinking

This piece of work clearly provides evidence for several aspects of Scientific Thinking, including the framing of the question, the use of concepts, and the formulation of explanations and design solutions. Consideration of alternative explanations or solutions is not evident in the text itself, but the depth and breadth of the bibliography suggests that a diversity of ideas was taken into account.

Scientific Tools and Technologies

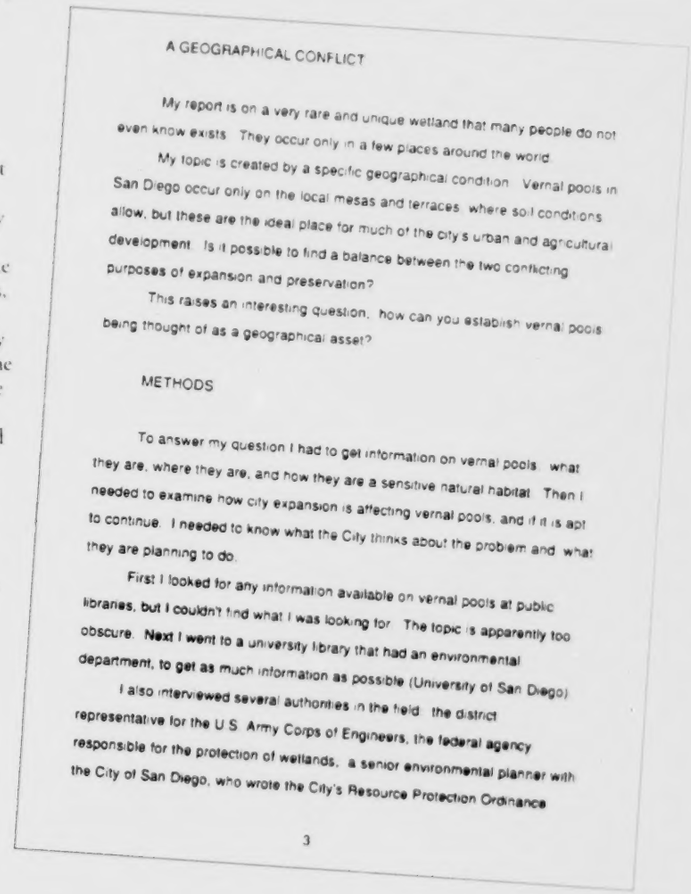
The extensive bibliography, consultation with experts, and the survey illustrate the acquisition of information from a variety of sources. The survey sample is not well thought out, however, and citation of sources in the text would be desirable.

Scientific Communication

This work provides evidence for several aspects of Scientific Communication—represents data and results in multiple way, e.g., maps, graphs and drawings; summarizes varied sources of evidence, e.g., the student's data, published reports, and interviews with experts; explains a scientific concept, e.g., the text and drawing on pages two to four are both good explanations of the vernal pool cycle; and communicates in a form suited to the purpose, i.e., the text succeeds in explaining and persuading.

Going beyond

This work meets the standard for Scientific Investigation. To meet the standard for Life Sciences Concepts, it would need to be accompanied by additional work of comparable quality demonstrating understanding at a molecular or cellular level. To meet the standard for Earth and Space Sciences, it would need to be accompanied by additional work of comparable quality demonstrating an understanding of the Earth in the solar system. To meet the standards for Scientific Thinking, Scientific Tools and Technologies, and Scientific Communication, it would need to be accompanied by work of comparable quality demonstrating direct observation and experimentation, collection and analysis of scientific data, and conclusions based on this evidence.



A GEOGRAPHICAL CONFLICT

My report is on a very rare and unique wetland that many people do not even know exists. They occur only in a few places around the world.

My topic is created by a specific geographical condition. Vernal pools in San Diego occur only on the local mesas and terraces, where soil conditions allow, but these are the ideal place for much of the city's urban and agricultural development. Is it possible to find a balance between the two conflicting purposes of expansion and preservation?

This raises an interesting question, how can you establish vernal pools being thought of as a geographical asset?

METHODS

To answer my question I had to get information on vernal pools: what they are, where they are, and how they are a sensitive natural habitat. Then I needed to examine how city expansion is affecting vernal pools, and if it is apt to continue. I needed to know what the City thinks about the problem and what they are planning to do.

First I looked for any information available on vernal pools at public libraries, but I couldn't find what I was looking for. The topic is apparently too obscure. Next I went to a university library that had an environmental department, to get as much information as possible (University of San Diego).

I also interviewed several authorities in the field: the district representative for the U.S. Army Corps of Engineers, the federal agency responsible for the protection of wetlands; a senior environmental planner with the City of San Diego, who wrote the City's Resource Protection Ordinance

3

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(RPO), the Station botanist at Miramar Naval Air Station, who is in charge of their vernal pool management plan on the land that has the largest number of pools remaining in the City of San Diego; a biologist working for RECON (Regional Environmental Consultants), a firm which is mapping the vernal pools for the City of Hemet, (another city in San Diego County facing the same issues); and finally a geographer working for SANDAG (San Diego Association of Governments), a regional organization that gathers, records, and analyzes data associated with regional planning and environmental issues. They answered many questions and offered their own ideas and information, including additional articles on my subject. I looked at several maps and photos of vernal pool locations, and charts of changing land use.

To decide how much education may be needed about vernal pools, I made a questionnaire, and surveyed two classrooms of elementary students, and a group of forty-two adults, trying to cover most age groups.

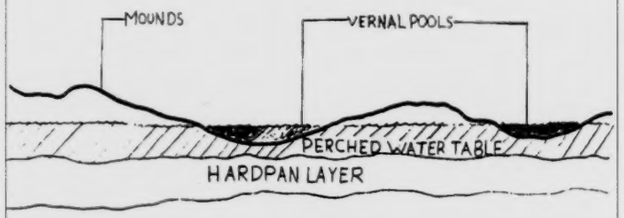
WHAT VERNAL POOLS ARE

Vernal pools are a unique and rare form of wetland. Wetlands are areas that are covered or soaked by water enough to support plants that grow only in moist ground. Some examples of wetlands are bogs, swamps, marshes, and edges of lakes and streams. These are what people think of when they hear "wetland". But vernal pools are different than these other types of wetlands. They are located on dry and flat places. No one would expect to find a wetland in such a dry area!

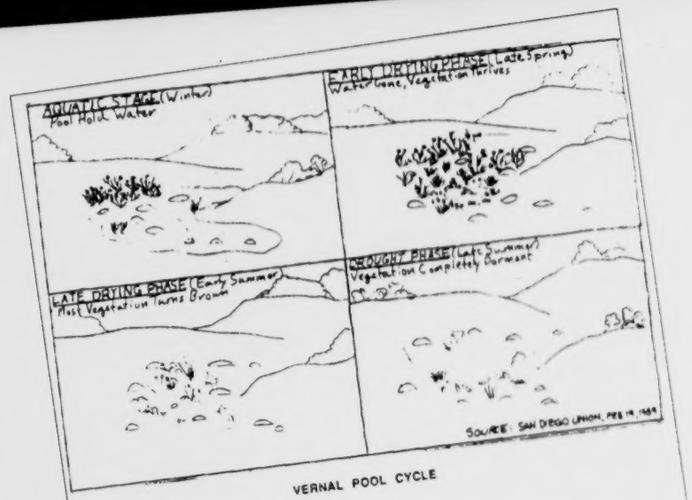
San Diego vernal pools are surrounded by small mounds called "mima mounds". The name mima mounds comes from the Mima Prairie near Olympia, Washington. People don't know for sure how mima mounds are formed. Some

think that they were formed by gophers piling up the earth. Others think that ice wedges from glaciers caused the upheaval, or maybe the wind pushed loose dirt, catching in clumps of shrubs. Mounds can be found on prairies or terraces with a hardpan or clay layer underneath.

Vernal pools are depressions between the mima mounds. In winter the pools are filled by rain storms. In spring the pools look their best, when plants are in full splendor. By summer the pools are dry and look only like a dry pothole. (See illustration of pool cycles and typical cross section.) A vernal pool does not dry by soaking into the ground; the layer of clay or rock underneath the pool prevents the water from soaking through. Instead they dry out from evaporation, or use by the plants. The mima mounds are not impervious so one pool tends to drain into another. Therefore, the pools have to be on flat land; the pools cannot be on a slope or the water would run off, and the pools would not be filled.



TYPICAL CROSS SECTION OF VERNAL POOL


AQUATIC STAGE (Winter)
Pool Hold Water
EARLY DRYING PHASE (Late Spring)
Water Gone, Vegetation Thrives
LATE DRYING PHASE (Early Summer)
Most Vegetation Turns Brown
DROUGHT PHASE (Late Summer)
Vegetation Completely Dormant
SOURCE: SAN DIEGO UNION, FEB 19, 1984

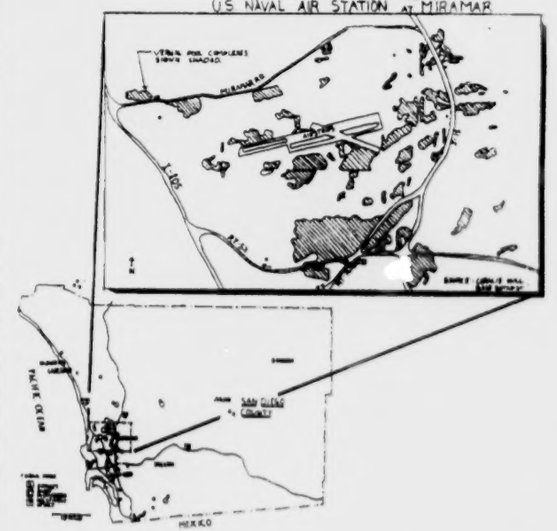
VERNAL POOL CYCLE

WHY VERNAL POOLS ARE SO IMPORTANT

Vernal pools are a very rare, specific habitat. Hardly any are left, so we don't have many to lose. There used to be vernal pools on many of the mesas and terraces of San Diego County, and the Central Valley of California. Now there are almost no vernal pools in the Central Valley, and an estimated 97% have been lost in San Diego County. An estimated 80% of the remaining pools in San Diego are located on Miramar Naval Air Station. (See map, next page.)

When Japanese students study biology, an important component of their work is to learn about the "organization of biotic communities: animal communities, plant communities; [and] changes in biotic communities: changes in animal communities, succession, distribution of living things...Instruction in 'distribution of living things'...should be made centering upon the ecological distribution, and geographical distribution of living things in the world should not be taught by mere naming of the living things."

Course of Study for Upper Secondary Schools in Japan, pp. 57-58.



VERNAL POOL DISTRIBUTION, SAN DIEGO COUNTY

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Work Sample & Commentary: *A Geographical Report* continued

1 Reading	2 Writing	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech Tools & Techniques	4 Learning & Self-mgmt Tools & Techniques	5 Tools & Techniques for Working With Others

Applied Learning

It does not take much to disturb a vernal pool. Even grazing or off road vehicle use in the summer, when pool species are dormant and people could think they are just a dry hole, can damage them. Most are disturbed by grading and flattening of their habitat, or by breakup of the impervious layer. With just flat land there would be no depressions for vernal pools to form; what would form would be "vernal mud". With no impervious layer the water would just sink into the ground, and would be there only for a short period of time, not enough for wetland plants.

The mima mounds have to be protected too. If the watershed for the pools is changed, the condition of the pools changes. If there isn't enough water from runoff, then all plant or animal life in them disappears, because they need enough moisture at the right time, to live. If there is too much water, then the pool may turn into another kind of wetland, such as a bog.

Although people have begun to study them, there is still a lot to learn. One thing scientists know is that they are a part of a larger environment. Many animals travel from other areas to feed on plants or animals , or drink from the vernal pools. For example, water fowl from many other places will stop at the pools to eat the fairy shrimp and snack on the plants.

Vernal pools have a large assortment of rare and exotic flora and fauna (plants and animals). Five of them are on the federal list of endangered species, and one more is a candidate for listing. The plants and animals in vernal pools are unusual because they have only developed recently compared to other changes in evolution. As scientists study the pools more intently they are finding more and more unknown species. There are temporary pools in other places around the world, but California's vernal pools are different because of their long drought phase, which causes the plants and animals to adapt to the climate. They go into a dormant phase. For example, fairy shrimp

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lay eggs before the drought which hatch when it gets moist enough to be active. Some plants, in a short period of time, develop seeds; others appear to die out, but quickly sprout again from the rain. Many of these species cannot survive outside vernal pools, and some are "endemic" (species found only in a very restricted geographical area).

PROTECTION TECHNIQUES

The first step is to try to keep development away from vernal pools. But to do this you first need to know where the pools are. Thanks to regional mapping efforts, existing vernal pools have been fairly well identified in San Diego County.

There are already laws against disturbances of vernal pools. You could go to jail or get fined a large sum of money for disturbing a wetland. The U.S. Fish and Wildlife Service protects the listed endangered species present, and the U.S. Army Corps of Engineers makes sure you don't fill any kind of wetland habitat, including vernal pools. The local office of the U.S. Army Corps of Engineers has submitted a proposal to Washington for a stricter permit process for vernal pools.

When possible the vernal pools should be part of a large preserve of open space. That way the pools would not be isolated islands, but part of their natural communities, and would be protected by a buffer of distance. Fences should not be put directly around the vernal pools unless it cannot be avoided, because it would keep some animals out, such as rabbits which spread plant seeds around when they eat them.

It is important to educate people about vernal pools so they know how important they are and what they look like, and so they know how to preserve

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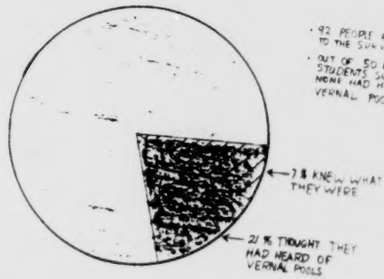
them. To see how much education may be needed in San Diego, I surveyed ninety-two people (forty-two adults and fifty elementary students to try to cover all age groups). I asked them if they had heard of vernal pools, and if they knew what they were. About 21% thought they had heard of them, but only 7% really knew what they were. (See pie chart.) I found that much education is needed.


• 92 PEOPLE RESPONDED TO THE SURVEY
• OUT OF 50 ELEMENTARY STUDENTS SURVEYED NONE HAD HEARD OF VERNAL POOLS
7 % KNEW WHAT THEY WERE
21 % THOUGHT THEY HAD HEARD OF VERNAL POOLS

SURVEY RESULTS

At N.A.S. Miramar the Station botanist has been putting articles dealing with vernal pools in almost every issue of the base newspaper. Now most people on the base know about vernal pools, and know how valuable they are.

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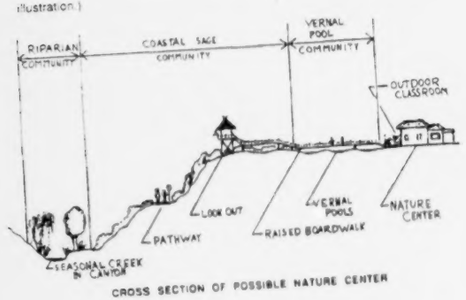
RECOGNIZING AN ASSET

Education is a key to preserving vernal pools. Vernal pools are very unique and we do not have many to lose. Making new ones does not work. Studies done at the University of California, Santa Barbara, have shown that after five years their complexity goes down.

First, vernal pools must be protected. There could be different ranges of accessibility, from remote (available to research only), somewhat accessible (good for guided seasonal visits), to readily accessible (which may have to be protected by fencing or supervision). The most accessible ones would be a great educational opportunity for the general public. The pools closer to development could be developed into nature centers, with raised boardwalks to protect the habitat, as is done over the hot springs in Yellowstone. (See illustration.)



CROSS SECTION OF POSSIBLE NATURE CENTER

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Interpretive signs and docents could provide information. Being very unique, vernal pools would make interesting learning centers. People would learn how the plants and animals adapt to the seasonal changes. This would teach people the importance of vernal pools, how complex they are, how to identify them, and how to preserve them when wet or dry. A park in the Sacramento area has an adjacent vernal pool with hiking trails around it; and it seems to work there because the people there know how important and delicate it is.

Ecotourism, a popular concept now, would be another idea. San Diego is a place where tourists already come. The very climate and geography that brings people here is what created vernal pools. Ecotourism would be easy to add to the other attractions, and would indirectly benefit the city. A tour company might be authorized to place advertisements to bring people to learn the importance of vernal pools and their ecosystem. With many people outside San Diego knowing about vernal pools and concerned about their well-being, there would be widespread support for vernal pool protection.

CONCLUSION

The problem of endangering vernal pools will not go away, because the City will need more land to develop. However, vernal pools remain a rare and unique wetland, and need protection. Even though there are laws made to protect them, pools are still being lost. Education is needed. Widespread education showing how important vernal pools are, and how easy they are to disturb, will create widespread support for protection.

A balance between expansion and preservation will not come easily, but if the public views vernal pools as a geographical asset, the balance will shift toward long-term vernal pool preservation.

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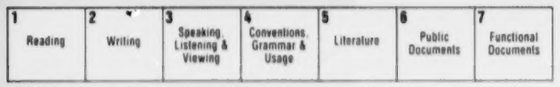
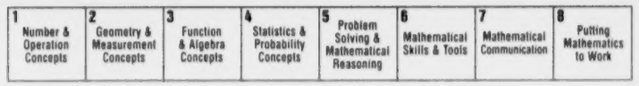
Work Sample & Commentary: *Are Oysters Safe to Eat?*



English Language Arts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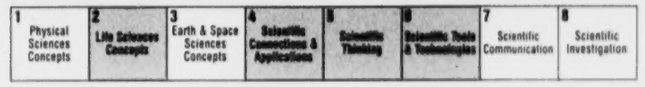
7 Mathematical Communication
8 Putting Mathematics to Work

Mathematics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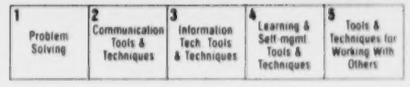
5 Scientific Thinking
6 Scientific Tools & Technologies
7 Scientific Communication
8 Scientific Investigation

Science


1 Problem Solving
2 Communication Tools & Techniques
3 Information Tech Tools & Techniques
4 Learning & Self-mgmt Tools & Techniques
5 Tools & Techniques for Working With Others

Applied Learning

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 56–57.

This piece of work comes from a project in which students share their work on the Internet. The General Accounting Office recently reported that more than half of 10,000 schools surveyed lacked modems and phone lines, and that only 35% of schools and 3% of classrooms currently have access to the Internet. We know this is an equity issue—that far more than 3% of the homes in the United States have access to the Internet and that schools must make sure that students' access to information and ideas does not depend on what they get at home. We have intentionally used these examples to make the point that Standard 6, Scientific Tools and Technologies, includes using telecommunications to acquire and share information. New Standards partners have pledged to create the learning environments where students can develop the knowledge and skills delineated here.

Science required by the task

The National Science Research Center encourages the establishment of student research centers in schools in the United States and around the world. The Center facilitates the exchange of information by publishing a journal of student investigations and by use of the Internet (nsrcmms@aol.com). It provides a standard format that students use to report their results. The format requires that students state a purpose and hypothesis; report their methods, data analysis, and conclusions; and suggest applications for their results. Students who use this format are therefore required to produce work related to parts of the following standards:

Standard 5, Scientific Thinking;

Standard 6, Scientific Tools and Technologies.

Science evident in this student work

This student decided to study whether oysters in her area were safe to eat. Therefore, in addition to the demands of the task for Standards 5 and 6, she also had to demonstrate understanding of:

Standard 2, Life Sciences Concepts;

Standard 4, Scientific Connections and Applications.

Some aspects of Standard 8, Scientific Investigation, are present in the work, but additional work would be required to fulfill the standard for an investigation at the high school level.

Life Sciences Concepts

This work provides evidence for parts of Standard 2, Life Sciences Concepts—interdependence of organisms, especially flow of energy, cooperation and competition, environmental constraints. The idea that animals harbor bacteria, often naturally occurring and sometimes environmentally introduced, is evidence for the interdependence of organisms. Many animals and bacteria live in cooperation with each other. Further, the use of agar as a growth medium and the identification of the need for sterile equipment provide evidence of an understanding of how bacteria grow.

Scientific Connections and Applications

This work provides evidence for parts of Standard 4, Scientific Connections and Applications—health, especially nutrition…disease; toxic substances… relationship to environment. The application section includes information on how the findings from this experiment would affect people who eat oysters. The connections between warmer summer months and higher bacteria levels are evidence for understanding toxic substances and their relationship to the environmental aspects of health. The understanding that most of these bacteria occur naturally and are not introduced by pollution and the caution regarding the risk to persons with "compromised health conditions" are evidence for the quality of work expected at the high school level.

Scientific Thinking

The student uses scientific reasoning strategies, scientific knowledge, and common sense to formulate questions about, understand, and explain a wide range of phenomena; that is, the student:

- **frames questions so that causes and effects can be distinguished; identifies variables that influence a situation and can be controlled;**
- **formulates and revises explanations and models based on evidence and logical argument, preserving significant information;**
- **proposes, recognizes, analyzes, considers, and critiques alternative explanations; distinguishes between fact and opinion.**

The work is well within the range appropriate for high school. The first paragraph in the section that offers the analysis of data provides the best evidence of the quality of expected for this standard. Discussion of unexpected results and critique of one's own procedures are the kind of scientific thinking that is required by this standard.

Scientific Tools and Technologies

The student uses tools and technologies to collect and analyze data; that is, the student:

- **uses a variety of traditional and electronic tools to directly, indirectly, and remotely observe and measure objects, organisms, and phenomena, being alert to accuracy and precision;**
- **records and stores data in a variety of formats, including databases, audiotapes and videotapes;**
- **analyzes data, taking steps to limit observer and sample biases, using concepts and skills from Mathematics Standard 4, Statistics and Probability Concepts;**
- **acquires information from print, electronic, and visual sources, including the Internet.**

The procedures are clearly reported, which makes it possible to find an abundance of evidence that this standard has been met. The use of sterile equipment, including the blender, the incubator, the agar, and sterile swabs, is necessary for this investigation. The entire report has an attention to detail that is reflected in the reporting of the procedures.

The report is not explicit about how the different bacteria were identified. Identifying bacteria is sophisticated work for a high school student—assistance would have been appropriate (and should have been acknowledged). The report would have been more complete and more easily replicated by others if this step had been explained.

Scientific Investigation

A full investigation includes:

- **questions that can be studied using the resources available;**
- **procedures that are safe, humane, and ethical; respect privacy and property rights;**
- **data that have been collected and recorded *(see also Science Standard 6)* in ways that others can verify, and analyzed using skills expected at this grade level *(see also Mathematics Standard 4)*;**
- **data and results that have been represented *(see also Science Standard 7)* in ways that fit the context;**
- **recommendations, decisions, and conclusions based on evidence;**
- **acknowledgment of references and contributions of others;**
- **results that are communicated appropriately to audiences;**
- **reflection and defense of conclusions and recommendations from other sources and peer review.**

This investigation started with one question: "Are raw Louisiana oysters safe to eat?" A review of the literature helped to sharpen the focus of the investigation so that the student focused on the effects of cooking the oysters as a way of eliminating bacteria. Because many people prefer to eat oysters raw, she did not answer her original question about the safety of eating raw oysters. In her conclusion, she reasoned that the summer months would be less safe but did not test that hypothesis nor any alternatives such as the freshness of the oysters regardless of the season.

The procedures were well documented so that another student could replicate the experiment and verify the results. It was not stated whether the blender was sterilized between oyster samples nor whether the petri dishes were covered during incubation. However, the attention to detail evident in other portions of this work suggest not a procedural error but a simple omission in the write up. This is supported in the data.

There is evidence of careful analysis when oyster size is identified as an important variable, though the amount of the sample in each condition is what should be controlled. The explanation of the difference between the bacteria types shows attention to detail, though the methods for identifying them are not reported. The rejection of the hypothesis and the appropriate communication of the results of the investigation are also elements of scientific investigation.

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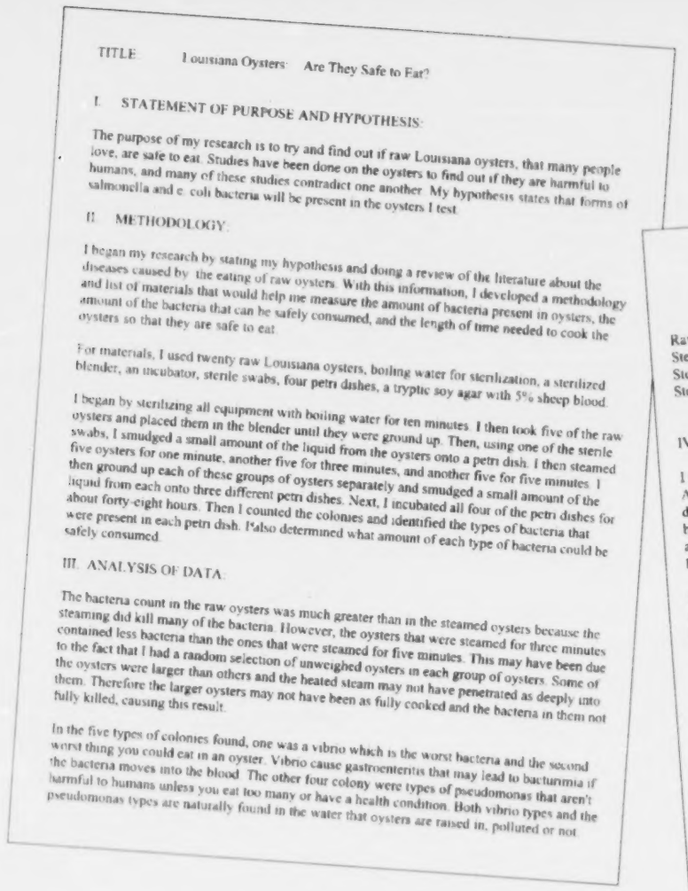
In addition to the modifications in the report suggested above, it would be necessary to repeat the experiment to meet the standard for Scientific Investigation at the high school level. Beyond the fact that multiple trials are generally good practice, controlling for oyster size and volume is necessary in this case. Further, it would appear from the data that there is some steaming time between one and three minutes that is sufficient for killing the bacteria. If this could be replicated and the time more precisely identified, the results would be more useful to people who would like to steam their oysters for the minimum amount of time required for safety.

Going beyond

This work provides evidence for the quality of work expected for parts of the standards for Life Sciences Concepts and for Scientific Connections and Applications. To meet the standards fully, it would need to be accompanied by work of comparable quality for other parts of these standards. To meet the standards for Scientific Thinking, Scientific Tools and Technologies, and Scientific Investigation, further work on the same problem would need to be presented to illustrate the aspects of revision and replication that are discussed above.



TITLE: Louisiana Oysters: Are They Safe to Eat?

I. STATEMENT OF PURPOSE AND HYPOTHESIS:

The purpose of my research is to try and find out if raw Louisiana oysters, that many people love, are safe to eat. Studies have been done on the oysters to find out if they are harmful to humans, and many of these studies contradict one another. My hypothesis states that forms of salmonella and e. coli bacteria will be present in the oysters I test.

II. METHODOLOGY:

I began my research by stating my hypothesis and doing a review of the literature about the diseases caused by the eating of raw oysters. With this information, I developed a methodology and list of materials that would help me measure the amount of bacteria present in oysters, the amount of the bacteria that can be safely consumed, and the length of time needed to cook the oysters so that they are safe to eat.

For materials, I used twenty raw Louisiana oysters, boiling water for sterilization, a sterilized blender, an incubator, sterile swabs, four petri dishes, a tryptic soy agar with 5% sheep blood.

I began by sterilizing all equipment with boiling water for ten minutes. I then took five of the raw oysters and placed them in the blender until they were ground up. Then, using one of the sterile swabs, I smudged a small amount of the liquid from the oysters onto a petri dish. I then steamed five oysters for one minute, another five for three minutes, and another five for five minutes. I then ground up each of these groups of oysters separately and smudged a small amount of the liquid from each onto three different petri dishes. Next, I incubated all four of the petri dishes for about forty-eight hours. Then I counted the colonies and identified the types of bacteria that were present in each petri dish. I also determined what amount of each type of bacteria could be safely consumed.

III. ANALYSIS OF DATA:

The bacteria count in the raw oysters was much greater than in the steamed oysters because the steaming did kill many of the bacteria. However, the oysters that were steamed for three minutes contained less bacteria than the ones that were steamed for five minutes. This may have been due to the fact that I had a random selection of unweighed oysters in each group of oysters. Some of the oysters were larger than others and the heated steam may not have penetrated as deeply into them. Therefore the larger oysters may not have been as fully cooked and the bacteria in them not fully killed, causing this result.

In the five types of colonies found, one was a vibrio which is the worst bacteria and the second worst thing you could eat in an oyster. Vibrio cause gastroenteritis that may lead to bacturmia if the bacteria moves into the blood. The other four colony were types of pseudomonas that aren't harmful to humans unless you eat too many or have a health condition. Both vibrio types and the pseudomonas types are naturally found in the water that oysters are raised in, polluted or not.

Data Table

	Number of Organism types	Number of colonies
Raw Oysters	5 types	100,000 +
Steamed for 1 min.	5 types	100,000 +
Steamed for 3 min.	1 type	1
Steamed for 5 min.	2 types	6

IV. SUMMARY AND CONCLUSION:

I conclude that cooking oysters substantially reduces the amount of bacteria present in oysters. A Person would have to cook oysters until they were shrivled and small if they wanted to destroy 99% of the bacteria present in oysters. The only way to be sure you are not eating bacteria from oysters that may compromise your health is to not eat oysters at all because there are certain northeastern bacteria that aren't killed by cooking. These are not a problem in Louisiana.

I reject my hypothesis. I did not find salmonella and e. coli bacteria in the oysters I tested. I did find bacteria that could make anyone sick not just those with compromised health as well as forms of bacteria that are only harmful if ingested in large quantities.

V. APPLICATION:

My project can be a source for people to turn to with questions about eating oysters in Louisiana. For instance, during the warmer summer months of the year, bacteria that are found naturally in the waters of oyster beds reproduce at a greater rate. Thus raw oysters eaten at these times will be more likely to contain high levels of bacteria which could harm healthy individuals if eaten in great quantity and individual with compromised health conditions. My research indicates that some individuals may want to stop eating raw oysters at this time of the year or thoroughly cook them.

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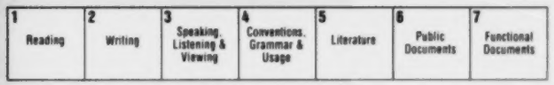
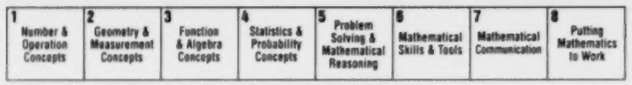
Work Sample & Commentary: *Compost Pile*



English Language Arts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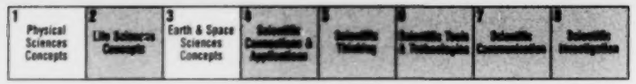
6 Mathematical Skills & Tools
7 Mathematical Communication
8 Putting Mathematics to Work

Mathematics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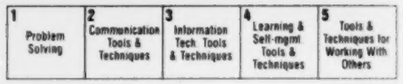
7 Scientific Communication
8 Scientific Investigation

Science


1 Problem Solving
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3 Information Tech Tools & Techniques
4 Learning & Self-mgmt Tools & Techniques
5 Tools & Techniques for Working With Others

Applied Learning

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 56–57.

Science required by the task

Students in a high school environmental science class were asked to design an experimental project that would improve some aspect of the environment at their high school. The students were given two class periods each week for one month to accomplish the task, which was given in addition to their regular class work. The class was in the fourth week of a one semester course in which the current unit of study was basic chemical concepts as they relate to ground water pollution. The students used texts and other resource materials. There was little teacher direction other than clarification. The students were given as much time as they needed to complete their work. The students worked in pairs and were allowed to seek feedback on their work and revise their reports.

Science evident in this student response

A pair of students chose to study the best location for a compost pile on the school grounds. To determine the location, they set up an experiment in which they controlled the amount of sunlight available to a compost column in a bottle. The column was used as a rough model of the actual pile. They selected two classroom locations similar in amount of sunlight available to the locations they might suggest for the real compost pile. They set up the experiment, kept track of their procedures, and recorded data over a period of several weeks. They made a recommendation to their principal based on their study. In addition to Standards 2, 5, 6, 7, and 8 required by the task, the explanations the students gave demonstrated an understanding of several unifying concepts in Standard 4. The assignment thus required them to provide evidence for parts of the following Science standards:

Standard 2, Life Sciences Concepts;

Standard 4, Scientific Connections and Applications;

Standard 5, Scientific Thinking;

Standard 6, Scientific Tools and Technologies;

Standard 7, Scientific Communication;

Standard 8, Scientific Investigation.

Scientific Investigation

This piece of work provides evidence for all but the last listed part of:

A full investigation, which includes:

- **questions that can be studied using the resources available.**

It would be impractical to create several full sized compost piles, so the students made a model of a compost pile using plastic soda bottles. This made the question about where the compost pile might best be located an answerable question.

- **procedures that are safe, humane, and ethical; respect privacy and property rights.**

The procedures explain where they got the instructions for making the model in step one, enabling other students to replicate the experiment. The statement in step five, "WASH your hands…" indicates both safety consciousness and the expectation that others may want to verify their results. The use of fine mesh cloth to control the fruit fly problem shows concern for the science classroom environment. The work also provides evidence of respect for others who use the school property when, in the conclusion, the students deal with the possible odor problem.

- **data that have been collected and recorded *(see also Science Standard 6)* in ways that others can verify, and analyzed using skills expected at this grade level *(see also Mathematics Standard 4).***

Data collection procedures, including the identification of the organisms, are documented well enough so that others could replicate the experiment. The data analysis is not documented in a quantitative way, but the qualitative report is sufficient for the purpose.

- **data and results that have been represented *(see also Science Standard 7)* in ways that fit the context.**

The drawing of the bottle and the presentation of the data, in both verbal and pictorial forms, are effective in this context. The careful use of language, for example, "stuff we believe to be fungi" and "four legs we could see, possibly mites," reflects a level of precision appropriate for high school students. The drawing of the insects thought to be mites shows eight legs; perhaps the students intended to say "four legs on each side."

- **recommendations, decisions, and conclusions based on evidence.**

The conclusion draws a conclusion based on the data: "the larger insects and worms reproduced faster in the full sun location." The recommendation takes account of this conclusion: "the compost pile be placed on the south side of the building…This location gets full sun all day and is close to a water faucet." It also takes account of other factors, e.g., need of water, direction of wind, distance from the new building, that would influence the decision to adopt their recommendation.

- **acknowledgment of references and contributions of others.**

Though they are not cited in bibliographic format, the references used are mentioned in the text.

- **results that are communicated appropriately to audiences.**

The conclusion section of the report could be given to the principal and substantiated by the preceding sections of the report.

- **reflection and defense of conclusions and recommendations from other sources and peer review.**

Evidence of peer review was not included in this report.

Life Sciences Concepts

The work shows understanding of the following important life science concepts related to interdependence of organisms: a basic understanding of populations, ecosystems, and food webs; organisms classified by shared characteristics; diverse populations helping to create a healthy ecosystem; living things demonstrating a structure/function relationship, enabling organisms to survive in an environment; populations usually controlled by the finite nature of resources (matter and energy).

The work on identifying the organisms in the experiment shows an understanding of the life science classification system that differentiates insects from non-insects. Likewise the work shows the dependence of one organism upon a specific food source (earwigs and fruit) and ties predicted results in population variations to observable fluctuations in another dependent population (earwigs and worms).

Scientific Connections and Applications

The ecosystem created in the compost bottle was dependent on light, moisture, and food sources. The organisms came into the system with the yard waste. The students provide evidence of work towards the Scientific Connections and Applications standard when they relate form to function, e.g., relating the claw on the earwig to catching and holding food. The compost bottle was a small scale model and controllable version of the larger compost pile recommended in the conclusions. This use of a model in which variables can be controlled gives strong evidence of abilities to use models to investigate and solve problems in the natural world.

The clearest understanding appears in the explanation of the connections between population size and growth and of the predator/prey relationship (earwigs and worms…nematodes, available food and larger insects…earwigs and sow bugs). This is classic cause and effect, constancy and change, and movement towards steady state.

Going beyond

This work meets the requirements for Scientific Investigation. To meet the standard for Life Sciences Concepts, it would be necessary to show additional work of similar quality, particularly at the cellular and molecular level. Additional work would also be required to meet the standard for Scientific Connections and Applications, particularly with respect to technology.

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Our Compost Pile Project:

Plan: We want to find out what kinds of insects help compost turn from just waste to useable mulch and soil helper. We also would like to know what conditions help to speed up the breaking down of the compost. Our final goal is to recommend the best placement of the school compost pile we are recommending to Mr. W. This will depend on light and water needed and if the pile needs insects that he might see as not desirable near a schoolv (roaches, flies etc.)

Procedure:

1. The materials we used for the Compost Column were : 8, 2 liter bottles and the cutting thing (with razor blade) and glue guns. We used the instructions for making the bottles from the Bottle Biology book.

2. Construct two bottles (see our drawing)

3. We filled the compost part of the bottles with grass clippings, fruit waste, and leaves. we put the same stuff in both bottles. We mixed the compost up in a pail and placed half in one and half in the other. We also measured the mass of the bottle with the compost in it to make certain. We adjusted the amount to account for a 12 gram difference in the bottles because of extra glue on one.

4. We put one bottle in a direct sunlight part of the room and the other in a location that only has sunlight in the morning. We selected right in the middle window in the back of the room facing south with full sun from 7AM until 6PM and on the east side of Mr. C.'s room where there is sun only from 7AM until about noon. We found that the south window also gets about 10 degrees hotter. This may effect our results (these two locations are similar to the sun times of our two proposed sites for the school compost pile).

5. We watered both bottles and recorded the amount of water added each day. This needed to be the same in both bottles because we did not want to get more than one variable in our light experiment.

5. We took out a small sample of the compost (YUCK) and examined it with a hand lens and the microscope! WASH your hands and only do this again when you really have to! We recorded our observations in the data. (later we voted to use gloves).

6. We did this for 2 weeks until we could identify some of the animals that came in with the compost and are helping to decompose the stuff (we think). We used a book on biology to help with identification. This was the most difficult part.

7. We were asked to throw the bottles away (it was very wasteful) after five weeks because they seemed to be the home of a big bunch of fruit flies. We decided to keep one compost column going and cover the top with a fine mesh cloth to keep the fruit flies in and continue our experiment. Also we wanted to use it when we present our idea of a compost pile to Mr. W.

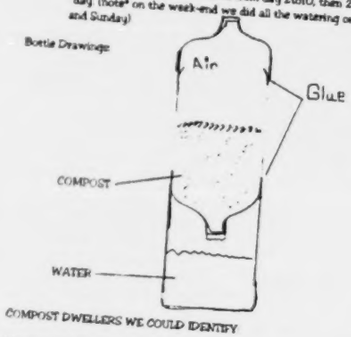
Data:

Mass of compost in bottle 1 : 312.0 g (I forgot to weigh the bottles at the end so we didn't have any data we could use so this is just here,but we didn't use it.)

Mass of compost in bottle 2 : 312.5g

Water Amounts: 100ml day 1 and 50 ml from day 2 to10, then 25 ml every other day. (note* on the week-end we did all the watering on Friday for Sat. and Sunday)

Bottle Drawings:



COMPOST DWELLERS WE COULD IDENTIFY

We could find lots of "stuff" we believe to be fungi. But, because we are interested most in the insects we just recorded it in the log as fungi and did not attempt this time to identify it.

Microscope:

A. Red to orange round [illegible] that have four legs we could see: poembly mites. We found lots of these on the underside of leaves and grass. We saw these only with the microscope.

B. Fine hair like worms. These were really thin and moved slower than we thought. We classified these as nematodes. There were, by sample count, the most abundant compost dwellers we could find. There were hundreds of them in almost every sample we looked at. There must be plenty of food for these. They were multiplying fast. The reference book says ,"they feed on decaying vegetation, bacteria and fungi which we had lots of in the bottle. We also thought that not many of the bigger insects ate these as a first choice or the population wouldn't have gone up so much each day. If we had watched it longer we think it would have leveled off and become the same day to day. Otherwise there would be more nematodes than compost.

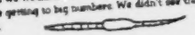
Hand Lens and Microscope:

C. Insects that looked like spiders with front claws. These we classified pseudo scorpions. According to the Biology book they do not have the upright tail with the stinger. We could only see the claws on the front and the two segment body similar to a spider. The claws are probably used like a lobster to catch and hold food.

D. Earwigs: these we recognized right away. They were by far the most fearsome looking insects we saw. The classification book says they are omnivores (like humans) and that in being a human can inflict a painful wound. We did not want to find out and voted to use rubber gloves from then on. They seemed to like the apple peal the best. We could always find one there. We might re-do this experiment and leave fruit out of one bottle to find out if they need fruit to survive. We think they eat plants but also eggs. We found lots of eggs under the larger leaves and that is where we found the earwigs mostly.

E. Sowbugs: These bugs did not look as frightening. They have a crustacean exoskeleton. It looks like a plate of armor or an armadillo. They moved slow but did not reproduce in large numbers while we did were doing this experiment. We only found three. They eat decaying vegetation mostly and there was lots. We aren't sure what kept their population so low. There might be some old weed killer on the grass or the earwigs eat them. We didn't have enough data to really say what kept their population low.

F. Worms: The only worms we saw (besides the microscopic ones) were small redworms. We only saw a few at first and them by week three there were hundreds. We decided that if these had been part of the food eaten by the earwigs we would see a lower population of these and a bunch more earwigs about when the worms were getting to big numbers. We didn't see this so they must not be the favorite meal for the earwigs.



Fruit Flys: We aren't sure where these came in, but the eggs must have been there to start with because we had none then by week four there were more than we could count flying around the room in the morning. The other explanation is that fruit flys were attracted to the compost and laid their eggs there during the experiment.

Other Observations:

The insect population was about the same in both bottles. But, the larger insects and worms reproduced faster in the full sun location. The compost seemed to be fluffier in the full sun. The one in the part sun went from 15 cm to 11 cm and stayed there for the rest of the experiment. The full sun went from 15 cm to 9 cm and then back up to 11 before the last week. We think the insects are giving air (aerating? spl) the compost. Most manuals say you have to turn compost to give it air. We think that the insects do some of this.

The compost was in smaller pieces by the end of the experiment. We did not disturb it much so we think that either the insects or the water or the heat helped break it down into smaller bits. But,

since the bits went smaller faster in the sunny bottle, the sun/temperature may have had a lot to do with it.

CONCLUSIONS:

Our recommendation is that the compost pile be placed on the south side of the building just behind the driver's ed. simulator trailer. This location gets full sun all day and is close to a water faucet. The insects we saw with our experiment were not harmful. We saw no roaches or house flies or maggots. We do think that you should only use yard waste and maybe fruit waste from the cafeteria (salad stuff is OK too). We did not use any meat food waste and that might draw more flies. If we have time we will experiment to find out which insects do the most good in a compost pile and see what we can add to the pile to make their numbers go up. We think that it is a waste to throw all that yard waste from all the grass away when we could make compost that other's could use for gardens or soil building. Since our experiments showed that the full sunlight bottle broke into smaller pieces faster and seemed to decompose faster, the full sun location would be better. This is because we would like the compost to break down quicker so that it can be used. The smell of the compost goes down after the first week. But, if you are constantly adding material to the pile it may stay a little smelly. The only disadvantage of this location is that the wind usually blows out of the southwest and the pile will be upwind from the new building. We thought that by placing it by the simulator it would be far enough away (112 feet we measured) to dilute the smell and not cause a problem. The smell is the only bad effect of this location. The location was the best sun and the closest to water. We think we could find a way to cut down the smell if it became a problem. We are willing to contact local lumberyards to see if they will donate the chickenwire and the 2 x 4s to construct a compost pile that we can start using in May. Thank you for your time and reading our lab report.

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In England, students in secondary school "should continue to carry out experimental and investigative work in a range of contexts...Through this work, they should develop their scientific knowledge and understanding. When they plan their work, pupils should be encouraged to use their own knowledge and understanding, and to support this with information from reference books and other secondary sources available to them. they should recognise the importance of using a quantitative approach where this is appropriate. they should have opportunities to develop precise, systematic and suitable ways of obtaining ways of obtaining evidence by making observations and measurements. Their evidence should allow them to draw valid and reliable conclusions. They should consider uncertainties in their measurements and observations. they should be helped to recognise that different ways of working are suited to different contexts. They should present their findings in a format appropriate to the task. They should evaluate evidence in the light of their knowledge and understanding of science."

Science in the National Curriculum, p. 23.

Work Sample & Commentary: *An Interview with Aspirin*

1 Reading	2 Writing	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech Tools & Techniques	4 Learning & Self-mgmt Tools & Techniques	5 Tools & Techniques for Working With Others

Applied Learning

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 56–57.

Science required by the task

Students were asked to write a report on the benefits and risks of common medications. Writing the report required that they demonstrate aspects of Standard 7, Scientific Communication. To the extent that they discussed the mechanisms of the medications, they would demonstrate understanding of Standard 1, Physical Sciences Concepts or Standard 2, Life Sciences Concepts; to the extent that they discussed health issues, they would demonstrate understanding of Standard 4, Scientific Connections and Applications.

Science evident in the student work

This comparison of the benefits and risks of three medications, Aspirin, Acetaminophen, and Ibuprofen provides evidence for parts of:

Standard 2, Life Sciences Concepts—behavior of organisms;

Standard 4, Scientific Connections and Applications;

Standard 7, Scientific Communication.

Scientific Communication

The construction of the interview questions frames the topic in a way that allows an explanation of each medication to be given in depth. Careful attention to details as important as the effects of overdoses and the way that aspirin chemically blocks pain, provides evidence for Scientific Communication—explain a scientific concept or procedure to other students. The work covers a range of information from uses to benefits and risks, giving a complete explanation and summarizing varied sources of information. It does not, however, consider the possible biases of these sources of information (one is from a pharmaceutical company) and this (apparently) uncritical acceptance of the information is a shortcoming of the piece.

The format for the comparison, an interview with each of these pain relievers, is an effective way of presenting information that could be tedious in other formats, though the format limits the depth of conceptual understanding that is demonstrated.

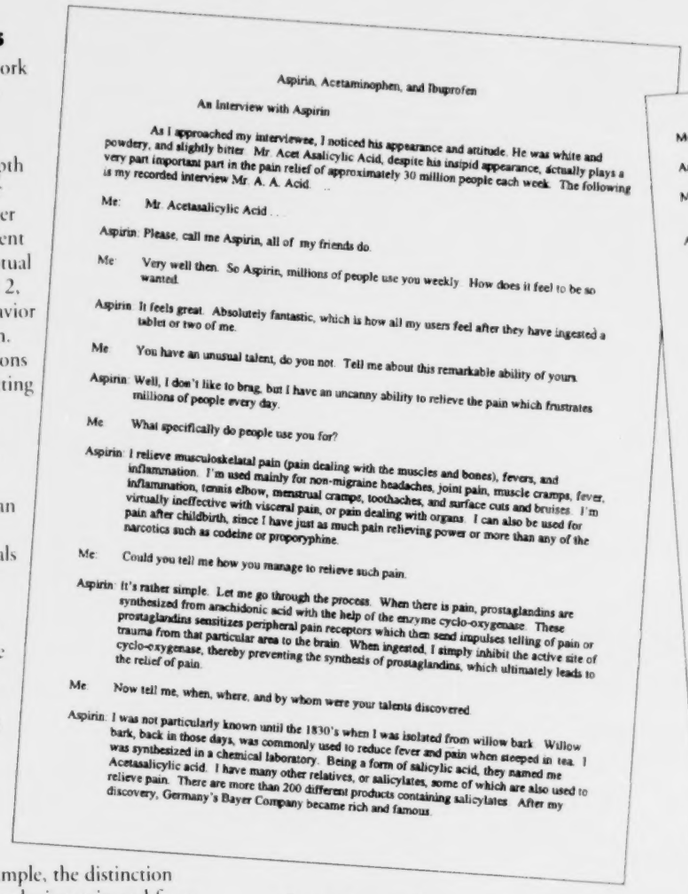
Life Sciences Concepts

At first glance, this piece of work looks like an engaging way to present a mass of detailed information, but it does not appear to demonstrate the depth of understanding expected for high school students. On closer inspection, however, it is evident that the work requires conceptual understanding from Standard 2, Life Sciences Concepts—behavior of organisms…nervous system. Examples include the discussions of the effect of aspirin on clotting and bleeding on the second page, and the explanation of analgesia and acetaminophen overdose on the third page. The understanding that human systems are regulated by the production of certain chemicals is consistent with the explanations throughout this work, though there is no evidence of understanding the biological processes involved.

Scientific Connections and Applications

Similarly, conceptual understanding of Scientific Connections and Applications—health, is evident throughout the piece. For example, the distinction between curing ailments and reducing pain and fever on the third page and the summary on the fourth page show that there is understanding behind the mass of detail.

Note that while there is mention of chemical terms, such as salicylates, there is no explanation of the underlying chemical concepts which would explain them. Therefore, the work does not provide evidence for Standard 1, Physical Sciences Concepts.



Aspirin, Acetaminophen, and Ibuprofen

An Interview with Aspirin

As I approached my interviewee, I noticed his appearance and attitude. He was white and powdery, and slightly bitter. Mr. Acet Asalicylic Acid, despite his insipid appearance, actually plays a very part important part in the pain relief of approximately 30 million people each week. The following is my recorded interview Mr. A. A. Acid.

Me: Mr. Acetasalicylic Acid . .

Aspirin: Please, call me Aspirin, all of my friends do.

Me: Very well then. So Aspirin, millions of people use you weekly. How does it feel to be so wanted.

Aspirin: It feels great. Absolutely fantastic, which is how all my users feel after they have ingested a tablet or two of me.

Me: You have an unusual talent, do you not. Tell me about this remarkable ability of yours.

Aspirin: Well, I don't like to brag, but I have an uncanny ability to relieve the pain which frustrates millions of people every day.

Me: What specifically do people use you for?

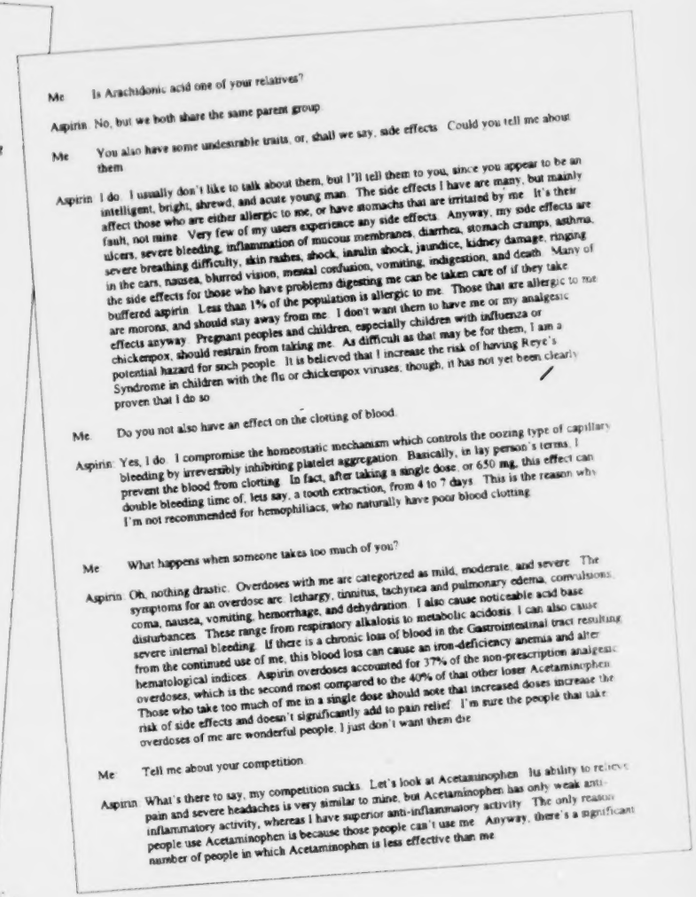
Aspirin: I relieve musculoskelatal pain (pain dealing with the muscles and bones), fevers, and inflammation. I'm used mainly for non-migraine headaches, joint pain, muscle cramps, fever, inflammation, tennis elbow, menstrual cramps, toothaches, and surface cuts and bruises. I'm virtually ineffective with visceral pain, or pain dealing with organs. I can also be used for pain after childbirth, since I have just as much pain relieving power or more than any of the narcotics such as codeine or proporyphine.

Me: Could you tell me how you manage to relieve such pain.

Aspirin: It's rather simple. Let me go through the process. When there is pain, prostaglandins are synthesized from arachidonic acid with the help of the enzyme cyclo-oxygenase. These prostaglandins sensitizes peripheral pain receptors which then send impulses telling of pain or trauma from that particular area to the brain. When ingested, I simply inhibit the active site of cyclo-oxygenase, thereby preventing the synthesis of prostaglandins, which ultimately leads to the relief of pain.

Me: Now tell me, when, where, and by whom were your talents discovered.

Aspirin: I was not particularly known until the 1830's when I was isolated from willow bark. Willow bark, back in those days, was commonly used to reduce fever and pain when steeped in tea. I was synthesized in a chemical laboratory. Being a form of salicylic acid, they named me Acetasalicylic acid. I have many other relatives, or salicylates, some of which are also used to relieve pain. There are more than 200 different products containing salicylates. After my discovery, Germany's Bayer Company became rich and famous.



Me: Is Arachidonic acid one of your relatives?

Aspirin: No, but we both share the same parent group.

Me: You also have some undesirable traits, or, shall we say, side effects. Could you tell me about them.

Aspirin: I do. I usually don't like to talk about them, but I'll tell them to you, since you appear to be an intelligent, bright, shrewd, and acute young man. The side effects I have are many, but mainly affect those who are either allergic to me, or have stomachs that are irritated by me. It's their fault, not mine. Very few of my users experience any side effects. Anyway, my side effects are ulcers, severe bleeding, inflammation of mucous membranes, diarrhea, stomach cramps, asthma, severe breathing difficulty, skin rashes, shock, insulin shock, jaundice, kidney damage, ringing in the ears, nausea, blurred vision, mental confusion, vomiting, indigestion, and death. Many of the side effects for those who have problems digesting me can be taken care of if they take buffered aspirin. Less than 1% of the population is allergic to me. Those that are allergic to me are morons, and should stay away from me. I don't want them to have me or my analgesic effects anyway. Pregnant peoples and children, especially children with influenza or chickenpox, should restrain from taking me. As difficult as that may be for them, I am a potential hazard for such people. It is believed that I increase the risk of having Reye's Syndrome in children with the flu or chickenpox viruses, though, it has not yet been clearly proven that I do so.

Me: Do you not also have an effect on the clotting of blood.

Aspirin: Yes, I do. I compromise the homeostatic mechanism which controls the oozing type of capillary bleeding by irreversibly inhibiting platelet aggregation. Basically, in lay person's terms, I prevent the blood from clotting. In fact, after taking a single dose, or 650 mg, this effect can double bleeding time of, lets say, a tooth extraction, from 4 to 7 days. This is the reason why I'm not recommended for hemophiliacs, who naturally have poor blood clotting.

Me: What happens when someone takes too much of you?

Aspirin: Oh, nothing drastic. Overdoses with me are categorized as mild, moderate, and severe. The symptoms for an overdose are: lethargy, tinnitus, tachypnea and pulmonary edema, convulsions, coma, nausea, vomiting, hemorrhage, and dehydration. I also cause noticeable acid base disturbances. These range from respiratory alkalosis to metabolic acidosis. I can also cause severe internal bleeding. If there is a chronic loss of blood in the Gastrointestinal tract resulting from the continued use of me, this blood loss can cause an iron-deficiency anemia and alter hematological indices. Aspirin overdoses accounted for 37% of the non-prescription analgesic overdoses, which is the second most compared to the 40% of that other loser Acetaminophen. Those who take too much of me in a single dose should note that increased doses increase the risk of side effects and doesn't significantly add to pain relief. I'm sure the people that take overdoses of me are wonderful people; I just don't want them die.

Me: Tell me about your competition.

Aspirin: What's there to say, my competition sucks. Let's look at Acetaminophen. Its ability to relieve pain and severe headaches is very similar to mine, but Acetaminophen has only weak anti-inflammatory activity, whereas I have superior anti-inflammatory activity. The only reason people use Acetaminophen is because those people can't use me. Anyway, there's a significant number of people in which Acetaminophen is less effective than me.

Going beyond

This work illustrates the quality expected for some aspects of Scientific Communication. However, to say that the student has met the standard, it would be necessary for the work to include some graphic representations of data and evidence of critical review of sources of information and identification of possible biases.

This work provides only marginal evidence for Life Sciences Concepts and Scientific Connections and Applications. To meet these standards, substantial additional evidence would be necessary.

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An Interview with Aspirin

Me How do you compare to Ibuprofen?

Aspirin Uh -- um -- umm. Ibuprofen. I've never heard the bum. I'm sure Ibuprofen is a loser just like Acetaminophen.

Me Well, thanks for your time, information, opinions, etc., etc.

An Interview with Acetaminophen

Acetaminophen is also an analgesic and antipyretic. This drug stars in several products such as Tylenol, Panadol, and Tempra, as well as many other non-aspirin pain relievers. This interview was done after that of Aspirin. The following is my interview with Mr. Acet Aminophen.

Me Mr. Aminophen, as an analgesic, what kind of ailments do you cure.

Acet Well, I don't really cure anything. I do, however, reduce pain and fever. I am commonly used for headaches, fever, and muscle and joint pains. I am also best for pain secondary to dental surgery and episiotomy.

Me Who are your consumers?

Acet Mainly children, who aren't supposed to take Aspirin. After all, Aspirin is the primary cause of death by poisoning among children under five. Aspirin has also been linked to the sometimes fatal complication of chickenpox and influenza viruses called Reye's Syndrome. Other users are Aspirin-allergic peoples, and people with hemophilia. They are also unable to take Aspirin. Other users are people who just trust me over Aspirin and Ibuprofen, knowing that I have no real side effects, unless taken in large overdoses.

Me Since I couldn't find anything about your history, we'll have to skip that part. So, how do you work to relieve pain?

Acet Unlike Aspirin and Ibuprofen who produce analgesia by a peripheral effect, I produce analgesia through the Central Nervous System (i.e. the brain and spinal cord). Since I work on the CNS, I cannot really do much with inflammation. And again, since you couldn't find the specifics, I can't really answer your question.

Me Tell me what happens to people who do take large overdoses of you.

Acet I mainly cause permanent damage to the liver and kidney. Symptoms of an Acetaminophen overdose are: nausea, vomiting, drowsiness, confusion, low blood pressure, and abdominal pain. Symptoms of severe overdoses are: CNS stimulation, excitement, cardiac arrythmias, low blood pressure, and delirium. These are followed by CNS depression with a stupor, hypothermia, shock, and coma. Jaundice may also occur in severe overdosages. Many of these symptoms come from my effect on the CNS.

Me How would you rate yourself to Aspirin and Ibuprofen.

Acet Well, I am better than them in the fact that I have no side effects and that I have no effect on platelet aggregation as both Aspirin and Ibuprofen do. I am just as effective and efficient as Aspirin is at relieving severe headaches and muscle pain. And though I am less efficient than Ibuprofen, meaning that it takes less of Ibuprofen of than myself to do what we do, I am just as effective as Ibuprofen is at relieving headaches and muscle pain. But of course, I'm still the best non-prescription analgesic in the business.

An Interview with Ibuprofen

Last, but not least, came my interview with Ibuprofen. Ibuprofen is a much more recently developed analgesic, antipyretic, and anti-inflammatory drug. In these respects, it is much like Aspirin. Ibuprofen is found in Motrin, Nuprin, and Advil. Now, my interview with Mr. Ibu Profen.

Me How do you work to reduce pain?

Ibu I work just as Aspirin does to relieve pain.

Me Mr. Profen, you are very similar to Aspirin, aren't you?

Ibu Yes, except I' m not chemically formulated the same and I am much better. Another difference is that I am classified as a nonsteroidal anti-inflammatory drug. Why I'm classified as something different than Aspirin is beyond me. Maybe it's because I am so much better.

Me How are you better than Aspirin?

Ibu Well, I have a reversible effect on platelet aggregation. The effect is reversed after 24 hours of the discontinuation of my use. I have a higher potential than aspirin for fast, long acting pain relief for mild to moderate pain.

Me How are you better than Acetaminophen.

Ibu I'm more efficient on a mg to mg basis than Acetaminophen as well as Aspirin. And I can reduce inflammation, fever, and pain whereas Acetaminophen can reduce only pain and fever.

Me You also have side effects. Could you tell me about them?

Ibu The only side effect I know of is my effect on platelet aggregation, which is like that of Aspirin except my effect is reversible. It is possible that I do have an effect on people that allergic to aspirin, but it's not proven. I don't know of any other side effects that I can cause.

Me What are the symptoms of an Ibuprofen overdose.

Ibu Symptoms are: nausea, vomiting, abdominal pain, lethargy, stupor, coma, nystagmus, dizziness, lightheadedness, hypotension, bridyeardea, tachnycardia, dyspensea, and painful breathing. Unlike some certain other analgesics, I only account for 15% of accidental overdoses with non-prescription analgesics. I guess people feel so relieved after the first dose, they realize they don't need much more.

Me Who uses you?

Ibu It's not who uses me, it's who can't use me. I'm not recommended for hemophiliacs. I am sometimes recommended for people allergic to Aspirin, but not often. Basically, there are very few people who can't use me.

A Comparative Summary on Aspirin, Acetaminophen, and Ibuprofen

Ibuprofen is more potent as an analgesic than either aspirin or acetaminophen. Ibuprofen, unlike aspirin, produces a reversible effect on platelet aggregation. Acetaminophen is preferred for those who have a history with hemophilia, for children, and for aspirin allergic people. Aspirin, despite it relative shortcomings, is still used as a common analgesic.

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The objectives for teaching the Natural Sciences to students in Norway instruct teachers to help students to "look after their own health and lives, and the health and lives of others;... communicate scientific and technological information of importance for everyday life in the community."

Curriculum Guidelines for Compulsory Education in Norway, p. 262.

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Work Sample & Commentary: *Erosion on the Minnehaha Creek*

1 Reading	2 Writing	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech. Tools & Techniques	4 Learning & Self-mgmt. Tools & Techniques	5 Tools & Techniques for Working With Others

Applied Learning

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 56–57.

Science required by the task

The National Science Research Center encourages the establishment of student research centers in schools in the United States and around the world. The Center facilitates the exchange of information by publishing a journal of student investigations and by use of the Internet (nsrcmms@aol.com). It provides a standard format that students use to report their results. The format requires that students state a purpose and hypothesis; report their methods, data analysis, and conclusions; and suggest applications for their results. Students who use this format are therefore required to produce work related to parts of the following standards:

Standard 5, Scientific Thinking;
Standard 6, Scientific Tools and Technologies.

Science evident in this student work

This student chose to study erosion, providing evidence for parts of:

Standard 3, Earth and Space Sciences Concepts—forces that shape the Earth; natural resource management.

To conduct the study, he had to learn how to measure erosion, by using an observational form and calculating an Erosion Index.

Because the NSRC format for publishing on the Internet does not include the maps, observer score sheets, or raw data, it is not possible to evaluate this piece of student work in relation to Standard 8, Scientific Investigation. The student's work might qualify for such review if that kind of information were included.

Earth and Space Sciences Concepts

The work provides evidence for understanding forces that shape the Earth, specifically erosion, and natural resource management, specifically erosion control. The list of hypotheses in the second paragraph is really a list of explanations. The list gives explanations of the mechanisms of erosion or erosion control, e.g., roots to hold the runoff, storm drains to channel the rain runoff.

Scientific Thinking
Scientific Tools and Technologies

The work shows that a number of steps have been taken to measure erosion. Nevertheless, the Erosion Index that plays a critical role in the study is not explained. The work provides evidence for high school level Scientific Thinking—frame questions, identify variables, and Scientific Tools and Technologies—measure…being alert to accuracy and precision, by including the following steps: deciding on a representative sample, developing an observation form with help from experts, training independent observers, and taking observations from both sides of the creek.

Scientific Investigation

As noted above, the format for publishing on the Internet does not include the maps, observer score sheets, or raw data. Therefore, it is not possible to evaluate this piece of student work as evidence for a full investigation as required for Scientific Investigation. A description of the Erosion Index, a clearer delineation of the seven erosion control factors, and the data that show the relationships among them would also be required.

Going beyond

This work provides evidence for the quality of work expected for part of the standard for Earth and Space Sciences Concepts. To say that the standard had been met, however, the work would need to be accompanied by work of comparable quality on other aspects of the Earth system. Fuller descriptions of the design, collection, and analysis of data would be required to meet the standards for Scientific Thinking, Scientific Tools and Technologies, and Scientific Investigation.

Title: Erosion on the Minnehaha Creek

I. Statement of Purpose and Hypothesis:

The Minnehaha weaves through the city as a quiet creek that adds to the charm, beauty, and wildlife of the city. The creek is a recreational park that allows fishing, tubing, canoeing, and walks along the bank. The banks are eroding in many places causing problems such as damage to yards, houses, and city parks. Narrower and lost walkways along the parks prevent bikes, running, and walking along the creek. In addition, a significant amount of funds is required to correct the damage every year caused by erosion. A recent television program talked about erosion in the creek as a major problem for Minneapolis Park Board.

For these reasons, I chose my project to find more ways to prevent erosion along the creek and eliminate these problems. The questions I would like to answer include whether erosion control factors such as bank vegetation, trees, rocks, and storm drains reduce the amount of erosion along the Minnehaha Creek. This study may provide answers on how we can prevent erosion along it's banks. I want to know if erosion, as measured by the Erosion Index, is more where there is less erosion control present along the Minnehaha Creek. Specifically, the hypotheses to test include: 1) Erosion, as measured by the Erosion Index, is more at narrow and deep bends along the creek. 2) Erosion, as measured by the Erosion Index, occurs at places with less vegetation. These are places where there are no roots to hold the soil from being washed away by the water runoff. 3) Erosion, as measured by the Erosion Index, occurs where storm drains are not located along the creek. These places have higher erosion due to runoff from the rain making gullies and crevices. 4) Erosion, as measured by the Erosion Index, occurs at places with less trees on the banks.

This study will tell us whether these factors are important in controlling erosion along the creek. If so, these factors can be changed or implemented to provide a cost effective way of preventing erosion.

II. Methodology:

This study design will be an observational study to quantify the amount of erosion and erosion control factors that occur along the Minnehaha Creek. I hopes to determine what factors play a role in erosion. Two independent observers will walk along a specific section of the creek to measure the

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amount of erosion and erosion control factors using the Erosion Index. I will obtain a map of about 10 blocks of the Minnehaha Creek from the Old Mill Dam in Edina to the city of Minneapolis. On the basis of on my preliminary observations, I feel this is a representative sample of the Creek that includes many areas of erosion and has had erosion control efforts completed to prevent erosion. In addition, this area is heavily used by pedestrians and is heavily populated with houses that may be effected by the erosion. First, I had to develop an index to score erosion and to score the presence of the erosion control factors. I did this with the help of the City of Minneapolis Park Board staff and specific references from my review of the literature. Then I designed a form for the observers to score the amount of erosion and erosion control factors as they walk along the creek. We needed two observers on both sides of the creek to make sure that the data collected was reliable. A score will be placed on the form for each block and each side of the creek inspected. Then I will add the scores up and compare the sum with the number in the erosion index that correlates to the bank and section. In addition, I will compare both of the numbers in a statistical analysis. This will include comparing the total of erosion control scores between blocks that have low erosion scores with an equal number of blocks that have high erosion scores.

III. Analysis of Data:

Three out of the 7 erosion control factors seem to correlate with less erosion or have a negative correlation with erosion. These are straight creek flow, shallow creek levels, and the rocks on the banks.

IV. Summary and Conclusion:

I have learned that most of the control factors are not a sure bet and that you cannot completely stop erosion. In addition, even if someone had all the factors they could not completely stop erosion. The best prevention is unfortunately not manmade and includes a straight creek and shallow water. If someone is trying to stop erosion and they do not live on a section of the creek that is straight, I would recommend that rocks and trees would work the best. Although the total correlation of all factors is close to zero the p-value (probability) is .83 which means that there is a big variance in the amount that erosion control factors effect erosion.

In general, I found out that when there were less Erosion Control Factors there was more erosion and when there was more Erosion Control Factors there was less erosion.

Application

I can apply this information in two ways. First, I can educate people on how to prevent erosion. Second, I can be more careful on how I treat the creek myself.

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Students in British Columbia, Canada, who are studying Earth Science are expected to: "describe the processes by which glaciers, running water, wind, and wave action weather and erode rock; give examples of erosional and depositional features formed by glaciers, running water, wind, and wave action; correlate common local sedimentary deposits with possible origins, methods of transport, and environments of deposition."

Earth Science 11, Geology 12: Curriculum Guide, p. 24.

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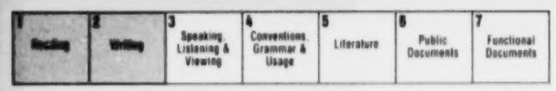
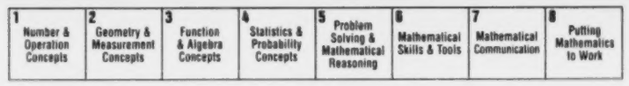
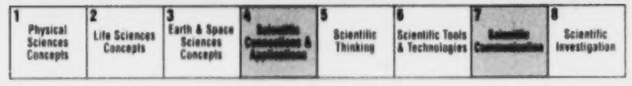
Work Sample & Commentary: *Air Pollution*



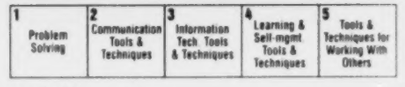
English Language Arts


1 Number & Operation Concepts
2 Geometry & Measurement Concepts
3 Function & Algebra Concepts
4 Statistics & Probability Concepts
5 Problem Solving & Mathematical Reasoning
6 Mathematical Skills & Tools
7 Mathematical Communication
8 Putting Mathematics to Work

Mathematics


1 Physical Sciences Concepts
2 Life Sciences Concepts
3 Earth & Space Sciences Concepts
4 Scientific Connections & Applications
5 Scientific Thinking
6 Scientific Tools & Technologies
7 Scientific Communication
8 Scientific Investigation

Science


1 Problem Solving
2 Communication Tools & Techniques
3 Information Tech Tools & Techniques
4 Learning & Self-mgmt Tools & Techniques
5 Tools & Techniques for Working With Others

Applied Learning

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 56–57.

Science required by the task

Students in a high school chemistry class were asked to write a report on pollution. In the report, they were to synthesize a variety of information in order to make it understandable to non-scientists.

Science evident in this student work

This student presented the information in the form of a story. Most of the information appears simply to be restated from the sources. However, the student made connections among important aspects of the topic. The links among concepts provide evidence for:

Standard 4, Scientific Connections and Applications.

The clear and coherent description and explanation for an audience unfamiliar with the topic provides evidence of work toward:

Standard 7, Scientific Communication.

Scientific Connections and Applications

The student understands:

- **big ideas and unifying concepts; for example, order and organization, models, systems, evolution and equilibrium, form and function, cause and effect, constancy and change;**
- **technology, including cost/benefit, constraints, feedback, risk;**
- **the designed world, including agriculture and industry;**
- **health, especially nutrition, exercise, and disease; toxic substances; safety; relationship to environment;**
- **historical and contemporary impact of science.**

An understanding of cause and effect is demonstrated in the explanation of the types of pollution (sulfur and nitrogen based), of their effect on the environment (acid rain), and of more specific damage to monuments and ancient buildings. The connection made between carbon monoxide and irregular heartbeats, for example, provides evidence for unifying parts of a system into a whole.

An understanding of the designed world and its effects on the environment is demonstrated in the balanced treatment of both designed and naturally occurring factors that affect environmental quality. For example, air quality is affected both by hydrocarbons that result from the combustion of fossil fuels and by hydrogen sulfide from swamps. The range of these examples shows a comprehensive understanding of pollution for work produced by a high school student.

The relationship between health and environment is also evident, e.g., "When sulfur was in acid form in water vapor, it greatly irritated the lungs, and when it was in sulfate particles…" [p. 4]. This passage also illustrates the combination of concepts from physical and life sciences. This unification of concepts from both physical and life sciences is evidence for another aspect of Scientific Connections and Applications.

Scientific Communication

The student communicates clearly and effectively about the natural world; that is, the student:

- **represents data and results in multiple ways; for example, numbers and statistics; drawings, diagrams, and pictures; sentences; charts and tables; models; and uses the most effective way to make the point;**
- **summarizes varied sources of evidence, including his or her own data and published reports;**
- **critiques published materials, including popular and academic sources;**
- **explains a scientific concept or procedure to other students;**
- **communicates in a form suited to the purpose and the audience; responds to critical comments with data and reasoning.**

The strength of this work is its use of a story format to engage the reader. It effectively communicates with a lay audience by moving from fairly technical information to highly readable examples, e.g., "they could combine with wet deposition; like rain, snow, sleet…." The ability to explain a scientific concept to other students is evident throughout this work sample.

Going beyond

The work includes information from three sources, at least two of which are relatively recent. There is no evidence, however, of examining those sources critically for accuracy or bias, nor did the student cite the works in the text. In fact, the author reported turning aside the technical books and selecting these sources from the juvenile section. The issue of bias is an important one in Scientific Communication, especially when the author's point of view may influence the reporting of information on controversial topics such as pollution. Therefore, to say that the standard had been met, this work would need to be accompanied by additional work demonstrating these critical aspects of Scientific Communication.

Note that there are a couple of misplaced apostrophes, e.g., "These pollution's were dangerous…" [p. 3] and "arrhythmia's" [p. 4]. Many technical words are spelled correctly but used inaccurately. For example, ozone is not an isotope of oxygen; ozone is an allotrope. Carbon dioxide (CO_2) is important in keeping the planet warm, but it is an overstatement to say that without CO_2 the Earth would be frozen. There is also confusion between the tropospheric (surface) and stratospheric ozone. The student's choice to turn from technical to popular sources may have introduced some of these errors. Alternatively, he may have felt that the format allowed some liberty with language. Accuracy is an important element of clear and effective communication. Therefore, work less flawed than this piece would be required to satisfy the standard for Scientific Communication.

English Language Arts

This work sample provides evidence for the quality of work expected for the following parts of the English Language Arts standards:

Standard 1, Reading—reads informational material.

Standard 2, Writing—produces a report.

Reading

The student reads informational materials to develop understanding and expertise and produces written or oral work that:

- **restates or summarizes information;**
- **relates new information to prior knowledge and experience;**
- **extends ideas;**
- **makes connections to related topics or information.**

This work provides evidence that the student:

- ▲ restates and summarizes large amounts of information on various kinds of air pollution;
- ▲ relates new information to prior knowledge through the use of a twelve year old character learning a body of material. For example, he relates the smells experienced by Sam to the more scientific causes of those smells, including the hydrogen sulfide in Midville swamp.

Writing

The student produces:

A report, in which the writer:

- **engages the reader by establishing a context, creating a persona, and otherwise developing reader interest;**
- **develops a controlling idea that conveys a perspective on the subject;**
- **creates an organizing structure appropriate to purpose, audience, and context;**
- **includes appropriate facts and details;**
- **excludes extraneous and inappropriate information;**
- **uses a range of appropriate strategies, such as providing facts and details, describing or analyzing the subject, narrating a relevant anecdote, comparing and contrasting,**

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naming, explaining benefits or limitations, demonstrating claims or assertions, and providing a scenario to illustrate.

This work provides evidence that the student:

- engages the reader by establishing a narrative context which he carries through to the final sentence of the piece, e.g., "Sam Young was a 12 year-old nerd" [p. 1]; "Sam was relieved that something was being done about air pollution, and also that he had all the information he needed to write a research paper" [p. 6]; and the final sentence: "Sam sat down and started to write, 'It was a dusky afternoon when I…' "[p. 6];
- develops a controlling idea: Sam, a twelve-year-old boy, searches for information that will help him with a research paper;
- creates an organizing structure: Sam, who has allergies, raises two questions for himself—"What was air?…Isn't [it] the stuff we breath, but then why was it polluted?" [p. 2]; he locates sources of information, the first two of which were too difficult; and he defines various types of pollution along with their dangers, causes, etc.;
- includes appropriate facts and details about air pollution;
- excludes extraneous and inappropriate information;
- uses a range of strategies, e.g., provides facts and details [p. 2, par. 3], differentiates among types and causes of air pollution, provides a scenario to illustrate [p. 1, par. 2].

The spelling and grammatical errors in this work sample do not detract from overall quality the work but would not be acceptable in polished writing.

Air Pollution

It was a dusky afternoon when Sam was riding his bicycle home from school Sam always rode home, and today was no exception Though today he took a different route than usual Usually, Sam took a quick shortcut through Midville park Sam knew that the route he was taking today was much longer, but it was worth to avoid the pollen that was in the park Sam had severe allergies to pollen His mother had warned him about the high pollen count that morning

The long route isn't much better than the short one The long route consisted of riding along a busy road, and then going by Midville swamp As Sam rode along the road, he started feeling nauseous, so he speed up He soon came across the swamp, which just happened to reek the odor of rotten eggs Sam suddenly came to a halt He got off his bike and went behind the nearest bush He decided that would be the best place to leave the lunch he had just eaten an hour ago He then hopped back on his bike, still not feeling much better, and raced home before he passed out as well

Sam Young was a 12 year-old nerd He was always hanging out at the library He knew Midville Library better than the librarians who worked there did The library was close to Sam's home, but so was everything else in Midville Midville was a small town, situated closely to a big city, which was conveniently named Big City

Sam was planning to go to the library again today This time he was going, not for fun, but to do some research for a research paper he had been assigned in his science class This project was about something new to him Air pollution was something which Sam knew nothing about In fact, Sam didn't know much about air, after all, he was only twelve years old

While Sam was riding his bike to the library, he pondered about air and its pollution "What was air?" he thought to himself "Isn't the stuff we breath, but then why was it polluted" His curiosity rose, and he became intrigued and excited about air pollution

When he arrived at the library, he raced toward the shelf where they kept the books on air and air pollution His heart was pounding as he opened that first book He started to read the book, but he suddenly stopped, feeling very confused and lost, as though he was reading a foreign language This book was full of funny names and symbols He checked the title again It read 'Quantitative Analysis of Air Pollutants' He opened another book, this one was called 'Study of Gaseous Pollution' This book was full of similar names and symbols, and just as confusing So Sam headed to the juvenile section of the library hoping there might be something easier to read He found several readable books on air pollution

Pollution was any form of contaminates which were present in the atmosphere in combination or quantities that could be harmful to plant and animal life Odors were a sign of a contaminate because air didn't smell Sam giggled as he remembered an incidence of his classmates flatulence As he read, he found out that there were three types of air pollution These types were gaseous, particulate, and aerosol pollution's Gaseous pollution was any unnatural gases that were put into the air This was easy enough to understand, but than it went on to say there were four types of gaseous pollutants These types were sulfur-based, nitrogen-based, carbon-based, and ozone

This was a little confusing, so went to the science section of the library and checked out a simple chemistry book Now everything was much clearer He read on in the air pollution book Sulfur-based air pollution was mainly the compound sulfur-dioxide Nitrogen-based pollution was composed of oxides of nitrogen (NO, and NO_2) Carbon based pollution was the same and nitrogen pollution, except with carbon instead of nitrogen Ozone was very different from the rest It was an isotope of Oxygen, which composed of three atoms of Oxygen (O_3)

These pollution's were dangerous for many reasons The sulfur and nitrogen-based pollution would combine with water vapor or particles in the air and produce acidic substances, which was referred to in the book as acid deposition They could combine with wet deposition, like rain, snow, and sleet, forming acid precipitation, or they could combine with dry deposition, which were airborne particles, and settle in and damage an ecosystem Acid rain damages forests, and kills plant and animal life It also can corrode and tarnish metals, erode stone and concrete, and discolor or weaken paper, fabrics, leather, and paints Ozone can damage rubber and textiles Sam wondered how many monuments, memorials, and ancient building have been damaged by acid rain There was another kind of pollution formed from oxides of nitrogen, ozone and a group of compounds called PAN, when they were all in the presence of hydrocarbons and light Sam wondered what PAN was He knew it couldn't be the kind that people cook with He pictured dozens of pans floating in the air He read on PAN was an abbreviation for peroxyacetylnitrate, which he left at that The pollution caused by all those compounds was called photochemical smog, which was also dangerous to plant and animal life

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Work Sample & Commentary: *Air Pollution* continued

1 Reading	2 Writing	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech. Tools & Techniques	4 Learning & Self-mgmt Tools & Techniques	5 Tools & Techniques for Working With Others

Applied Learning

Then, Sam stumbled across some more interesting information. He found that these gaseous pollutants were harmful to people. Carbon monoxide prevents oxygen from getting to body tissues and causes more arrhythmia's, irregular heartbeats, than were considered normal, which can trigger heart attacks. Nitrogen dioxide was shown to cause lung cancer and respiratory infections. Sulfur dioxide irritated the lungs and aggravated respiratory diseases. When sulfur was in acid form in water vapor, it greatly irritated the lungs, and when it was in sulfate particles, it could damage lung tissue. Ozone was also poisonous to people.

Sam read on and discovered that some of this pollution was beneficial. Carbon dioxide helps to keep the planet warm. It allows the short waves of solar radiation to pass through the carbon dioxide and to heat the planet. However, it doesn't let the long waves of heat radiated from the earth to pass through the atmosphere, keeping the heat on the earth. The book went on to say that without carbon dioxide, the earth's temperature would be about 0°F instead of the normal 59°F. Ozone blocked the sun's harmful ultraviolet rays from reaching the earth's surface. Ozone does this high in the atmosphere where it has a layer of its own. However, now that layer was being depleted by other pollutants. There was a 50% decrease in the ozone layer over Antarctica. This was called the ozone hole. Every 1% loss from the whole ozone layer meant an increase of the potential of skin cancer by 5 to 7%. Sam was shocked. These pollutants had the ability to destroy plants, animals, ecosystems, the earth, and most of the human race. Then he realized that he had only studied gaseous pollutants. He still had to cover the other two types of pollutants.

Particulate pollutants were pollutants that float in the air. These include pollutants like dust, pollen, mold, ragweed. Sam was familiar with these pollutants. They didn't need much explanation. However other particulate pollutants included toxic elements such as cadmium, arsenic, chromium, mercury, beryllium, and lead. These elements combined with other particles, and were very dangerous. There were also other volatile, organic compounds which polluted the air like vinyl chloride and benzene. Then he read about another type of particulate pollution which was radioactive. This was radioactive fallout. The book mentioned something about some place in Russia called Chernobyl. A nuclear power plant had exploded emitting lots of radioactive fallout which included the radioactive cesium-137. There were also others which weren't part of the explosion, but still pollutants. These included iodine-131, uranium, radium, and dioxin. When radium decayed, it formed a dangerous gas called radon. Dioxin could cause severe forms of acne and other diseases. Radiation could cause cancer, mutations, and have other possibly fatal consequences. Sam felt a chill run down his spine. He was scared and he still had one more form of air pollution to study.

The last form of air pollution was aerosol pollution. These pollutants were particles which stay in air for a very long time. These pollutants include CFC's, which contributed to the depletion of the ozone layer. There isn't much information to cover for this form of pollution, so Sam decided to move on. His next question was, "Where do these pollutants come from?"

There were a great number of causes listed in the book Sam read. These were divided into two categories: nature-made, and man-made. The man-made causes included a number of things. The burning of fossil fuels for energy was the main cause.

Industrial and power plants were listed as the source of 90% of the sulfur dioxide and 50% of the oxides of nitrogen emissions in the U.S. The organic pollutants came from plastic and chemical manufacturing plants. Particulate pollutants came from metal smelters, paper mills, oil refineries, and other plants similar to those. The incomplete combustion of gasoline, which was a volatile mixture of flammable liquid hydrocarbons, also produces oxides of nitrogen and hydrocarbons which both cause photochemical smog. Nature-made polluters were volcanoes, which spew particles and sulfur dioxide all over. Others could be forest fires, and plants and trees which give off pollen. Swamps give off Hydrogen Sulfide (H_2S) which smells like rotten eggs and can be dangerous in great quantities. Sam remembered his trip through Midville swamp. Now knew the causes and effects, but not the solutions.

The last chapter in his book covered solution. There weren't any definite solutions, or at least anything that could replace the burning of fossil fuels. However, there were other sources of energy. These included solar power, hydropower, and geothermal energy. Scientists were also working on new form of energy by the fusion of the hydrogen isotope deuterium. Many laws and regulations were made by the government to slow down pollution. In 1986, sanctions were placed on cities like Denver, Atlanta, and L.A. Those sanctions didn't do much, so a stricter Clean Air Act was passed through Congress in 1990 with a deadline of 5 years for all the cities to meet those standards. Sam was relieved that something was being done about air pollution, and also that he had all the information he needed to write a research paper.

Sam sat down and started to write, "It was a dusky afternoon when I

References

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Gutnik, Martin J., The Challenge of Clean Air, Enslow Publishers, Inc., New Jersey, 1990

Air Pollution, Prentice Hall, Inc.

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Samples of student work that help explain "how good is good enough" for these standards can be found immediately following these pages.

To see how these performance descriptions compare with the expectations for middle school and high school students, turn to pages 118–122.

The standards for Applied Learning have been revised substantially since the last published draft of these standards. Contact New Standards for information about the content framework that has provided the foundation for the Applied Learning standards.

1. Problem Solving

Apply problem solving strategies in purposeful ways, both in situations where the problem and the desired outcomes are clearly evident and in situations where they are not.

The student completes projects involving at least two of the following kinds of problem solving each year and, over the course of high school, projects involving all three kinds of problem solving.

- **Designing: identifying needs that could be met by new products, services, or systems, and creating solutions for meeting them;**
- **Planning and Organizing: taking responsibility for all aspects of planning and organizing an event or activity from concept to completion, making good use of the resources of people, time, money, and materials and facilities;**
- **Improving a System: developing an understanding of the way systems of people, machines, and processes work; troubleshooting problems in their operation; and devising strategies for improving their effectiveness.**

A single project may involve more than one kind of problem solving.

DESIGNING

The student designs a product, service, or system to meet an identified need; that is, the student:

- **develops a design proposal that:**
  - **shows how the ideas have been developed;**
  - **reflects awareness of similar work done by others and of relevant design standards and regulations;**
  - **justifies the choices made, for example, with reference to functional, aesthetic, social, economic, and environmental considerations;**
  - **describes, where relevant, the principles on which decisions were based, such as, aesthetic, mathematical, and scientific;**
  - **establishes criteria for evaluating the product, service, or system;**
  - **uses appropriate conventions to represent designs;**
  - **communicates clearly so that a peer or colleague could use it;**
- **organizes, implements, and adjusts the production process to:**
  - **achieve specified standards of quality and safety;**
  - **make efficient use of time and resources;**
- **evaluates the product, service, or system in terms of the criteria established in the design proposal, using:**
  - **information gathered from impact studies or product testing or market research, as appropriate;**
  - **comparisons with similar work done by others.**

Examples of designing include:

- designing software for managing portfolio work *(see also Applied Learning Standards 2 and 4);*
- designing a vehicle to enter in a competition *(see also Applied Learning Standards 2 and 5; Science Standard 1);*
- designing a plan for development of a park recreation area *(see also Applied Learning Standards 2 and 5; Science Standards 3 and 4);*
- designing and building a staircase *(see also Applied Learning Standard 2; Mathematics Standard 2);*
- designing a building *(see also Applied Learning Standard 2; Mathematics Standard 2);*
- designing a market research service, providing advice on best-value products *(see also Applied Learning Standards 3 and 5; Mathematics Standard 4);*
- designing a business plan for publication of a magazine *(see also Mathematics Standards 3 and 8);*
- designing and building a cantilevered wooden deck *(see also Applied Learning Standard 2; Mathematics Standard 2);*
- designing a tourist guide for the local area *(see also Applied Learning Standards 2, 3, and 5; English Language Arts Standard 7);*
- designing a tutoring program in desktop publishing *(see also Applied Learning Standards 3 and 5).*

PLANNING AND ORGANIZING

The student plans and organizes an event or activity; that is, the student:

- **develops a planning schedule that:**
  - **is sensible in terms of the goals of the event or activity;**
  - **is logical and achievable;**
  - **reflects research into relevant precedents and regulations;**
  - **takes account of all relevant factors;**
  - **reflects strategic thinking;**
  - **communicates clearly so that a peer or colleague could use it;**
- **implements and adjusts the planning schedule in ways that:**
  - **achieve specified standards of quality;**
  - **make efficient use of time, money, people, resources, facilities;**
  - **reflect established priorities;**
  - **respond effectively to unforeseen circumstances;**
- **evaluates the event or activity using qualitative and quantitative methods to determine:**
  - **the success of the event or activity in terms of its established purposes;**
  - **aspects of the event or activity that could have been improved by better planning and organization and the ways by which the improvements could have been achieved;**
  - **recommendations for planning and organizing subsequent similar events or activities.**

Examples of planning and organizing an event or activity include:

- organizing a public exhibition of student artwork *(see also Applied Learning Standard 4);*
- organizing a weekend volunteer cleanup of a neighborhood;
- arranging a series of career information seminars *(see also Applied Learning Standard 5);*
- organizing a community festival to promote local businesses;
- organizing a team sports tournament *(see also Mathematics Standards 3 and 8);*
- organizing a schedule for practices and events at the school gymnasium and swimming pool, taking account of home and away games, junior varsity and varsity, and boys' and girls' teams *(see also Mathematics Standards 3 and 8).*

IMPROVING A SYSTEM

The student troubleshoots problems in the operation of a system in need of repair or devises and tests ways of improving the effectiveness of a system in operation; that is, the student:

- **explains the management and structure of the system in terms of its:**
  - **logic, sequences, and control;**
  - **impact;**
  - **operating principles, that is, the mathematical, scientific and/or organizational principles underlying the system;**
- **analyzes the design and management of the system, taking account of its functional, aesthetic, social, environmental, and commercial requirements, as appropriate, and using a relevant kind of modeling and systems analysis;**
- **evaluates the operation of the system using qualitative methods and/or quantitative measurements of performance;**
- **adapts techniques to control and manage the system in order to improve its performance by:**
  - **identifying, testing, and adjusting sub-systems;**
  - **developing and testing strategies to optimize performance.**

Examples of troubleshooting problems in the operation of a system or improving the effectiveness of a system in operation include:

- troubleshooting and repairing faults in the operation of an automobile, tractor, or computer based communications system;
- customizing applications software for financial management to better suit a specific use *(see also Applied Learning Standards 2, 4, and 5);*
- improving the system of waste management in a community access area *(see also Applied Learning Standard 2; Science Standards 2 and 4);*
- improving the yield of a farm or garden plot *(see also Applied Learning Standard 2; Science Standards 2 and 4);*
- improving the system for emergency evacuation of the school *(see also Applied Learning Standards 2 and 5).*

2. Communication Tools and Techniques

Communicate information and ideas in ways that are appropriate to the purpose and audience through spoken, written, and graphic means of expression.

The student makes an oral presentation of project plans or findings to an audience with expertise in the relevant subject matter; that is, the student:

- **organizes the presentation in a logical way appropriate to its purpose;**
- **adjusts the style of presentation to suit its purpose and audience;**
- **speaks clearly and presents confidently;**
- **responds appropriately to questions from the audience;**
- **evaluates the effectiveness of the presentation.**

Examples of oral presentations include:

- presenting designs for a building or cantilevered wooden deck to an audience including an architect and civil engineer; or designs for a vehicle to an audience including a person with expertise in electronics *(see also Applied Learning Standards 1 and 5);*
- presenting proposals for design of a recreation area to the local parks authority *(see also Applied Learning Standard 1 and 5);*
- presenting findings of research into the system for emergency evacuation of the school to a panel including representatives of the police and fire departments *(see also Applied Learning Standards 1, 2, and 5);*
- presenting a report on improving the yield of a farm or garden plot at an agricultural field day or horticultural show *(see also Applied Learning Standard 1).*

The student prepares a formal written proposal or report to a community organization or business; that is, the student:

- **organizes the information in the proposal or report in a logical way appropriate to its purpose;**
- **produces the proposal or report in a format similar to that used in professionally produced documents for a similar purpose and audience.**

Examples of written proposals and reports include:

- submitting a proposal for marketing software to a software design company *(see also Applied Learning Standards 1 and 4);*
- producing a submission to a community organization in response to its request for a proposal to develop customized financial management software *(see also Applied Learning Standards 1, 4, and 5);*
- writing a briefing for the school board on results of the investigation of the system for emergency evacuation of the school *(see also Applied Learning Standards 1 and 5).*

Communication Tools and Techniques Performance Descriptions continued on the following page

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2. Communication Tools and Techniques

(continued)

The student develops a multi-media presentation, combining text, sound, and images; that is, the student:
- **selects an appropriate medium for each element of the presentation;**
- **uses the selected media skillfully, including editing and monitoring for quality;**
- **makes smooth transitions between the elements of the presentation;**
- **achieves coherence in the presentation as a whole;**
- **communicates the information effectively, testing audience response and revising the presentation accordingly.**

Examples of multi-media presentations include:
- developing a presentation of proposals for design of a recreation area, combining video, graphics, and text *(see also Applied Learning Standards 1 and 5);*
- making an oral presentation incorporating electronically produced graphics and videotape to explain proposals for improving waste management *(see also Applied Learning Standard 1);*
- developing a videotaped guide to tourist attractions in the area, combining music, still and moving images, and text *(see also Applied Learning Standards 1, 3, and 5).*

The student translates information from one format to another; that is, the student:
- **chooses a different format appropriate for presenting information to better suit the purpose for communicating it;**
- **checks that the information has been translated accurately into the new format;**
- **justifies any changes made in the information, including the omission of material irrelevant to the purpose of the communication.**

Examples of translating information from one format to another include:
- translating from graphic to pictorial, e.g., producing sketches to show how the cantilevered wooden deck or staircase will look when it is constructed *(see also Applied Learning Standards 1 and 4);*
- translating from numerical to flow chart, e.g., translating data into a flow chart showing student traffic flow in an emergency evacuation from the school *(see also Applied Learning Standards 1 and 5);*
- from detailed written report to summary of points, e.g., summarizing a geological survey report into a briefing note to inform decision making on proposals for development of a park recreation area *(see also Applied Learning Standards 1 and 5).*

3. Information Technology Tools and Techniques

Use information technology to collect, analyze, organize, and present information.

The student:
- **sets up and operates computer equipment and associated peripherals;**
- **troubleshoots problems in operating computer equipment and software;**
- **uses on-line sources to exchange information for specific purposes.**

Examples of using information technology tools and techniques include:
- relocating and setting up computer equipment to conduct training sessions in the use of desktop publishing software *(see also Applied Learning Standards 1 and 5);*
- using HyperCard to produce an electronic tourist guide to the local area, solving problems encountered in designing a stack for the purpose *(see also Applied Learning Standards 1, 2, and 5);*
- creating a Home Page to provide information on a market research service *(see also Applied Learning Standards 1 and 5).*

4. Learning and Self-management Tools and Techniques

Manage and direct one's own learning.

The student learns from adult role models; that is, the student:
- **consults with and observes adult role models at work and identifies the elements of their work roles and the qualities of the their work products;**
- **analyzes the work performance of adult role models to determine the critical demands of the role, such as demands for knowledge and skills, judgment and decision making;**
- **takes account of analyses of role models in planning and conducting his or her own project activities.**

Examples of learning from adult role models include:
- shadowing a software designer at work *(see also Applied Learning Standards 1 and 2);*
- undertaking volunteer work in a community organization and assisting in the management of financial records *(see also Applied Learning Standards 1, 2, and 5);*
- gaining work experience in a museum and studying the work of a curator in mounting an exhibition *(see also Applied Learning Standards 1 and 2).*

The student reviews his or her own progress in completing work activities and adjusts priorities as needed to meet deadlines; that is, the student:
- **develops and maintains work schedules that reflect consideration of priorities;**
- **manages time;**
- **monitors progress towards meeting deadlines and adjusts priorities as necessary.**

Examples of using tools and techniques for reviewing own progress include:
- maintaining project log books;
- using project management software;
- developing flow charts for determining the sequence in which tasks need to be tackled.

The student evaluates his or her performance; that is, the student:
- **establishes expectations for his or her own achievement;**
- **critiques his or her work in light of the established expectations;**
- **seeks and responds to advice and criticism from others.**

Examples of using tools for evaluating one's own performance include:
- having a friend videotape an oral performance to allow for review;
- asking a professional in the relevant field to review a draft design;
- asking colleagues to review a draft report.

5. Tools and Techniques for Working With Others

The capacity to work with others to achieve a shared goal and contribute to on-the-job learning and to respond effectively to the needs of a client.

The student participates in the establishment and operation of self-directed work teams; that is, the student:
- **identifies the range of knowledge and skills required for a given project;**
- **defines roles and shares responsibilities among team members;**
- **sets objectives and time frames for the work to be completed;**
- **establishes processes for group decision making;**
- **reviews progress and makes adjustments as required.**

Examples of working in teams include:
- working in a team to design and build a vehicle to enter in a competition *(see also Applied Learning Standards 1 and 2);*
- working in a team to design a recreational area *(see also Applied Learning Standards 1 and 2);*
- working in a team to organize a series of seminars on careers *(see also Applied Learning Standard 1).*

The student plans and carries out a strategy for introducing others into a work program; that is, the student:
- **establishes learning goals;**
- **plans a sequence of activities designed to achieve the learning goals;**
- **monitors the learning process and revises activities accordingly;**
- **evaluates the success of the strategy and identifies aspects of the process that could have been improved and the ways by which the improvements could have been achieved.**

Examples of introducing others into a work program include:
- responding to growth in demand for a market research service by including a partner in the enterprise *(see also Applied Learning Standards 1 and 3);*
- providing training to other students on how to develop and conduct a tutoring program, based on experience in devising and running a tutoring program on desktop publishing *(see also Applied Learning Standards 1 and 3);*
- including a student new to the school in an ongoing project, such as a project to design a proposal for use of a park recreation area *(see also Applied Learning Standards 1 and 2).*

The student completes a task in response to a commission from a client; that is, the student:
- **negotiates with the client to arrive at a plan for meeting the client's needs that is acceptable to the client, achievable within available resources, and includes agreed-upon criteria for successful completion;**
- **monitors client satisfaction with the work in progress and makes adjustments accordingly;**
- **evaluates the result in terms of the negotiated plan and the client's evaluation of the result.**

Examples of responding to client needs include:
- producing a tourist guide to the local area at the request of the local tourist authority *(see also Applied Learning Standards 1, 2, and 3);*
- customizing applications software for financial management at the request of a community organization *(see also Applied Learning Standards 1, 2, and 4);*
- conducting an investigation of procedures for emergency evacuation of the school in response to a request from the school board *(see also Applied Learning Standards 1 and 2).*

These performance descriptions contain extensive cross-referencing, both between Applied Learning and English Language Arts, Mathematics, and Science, and among the Applied Learning standards.

The cross-referencing to English Language Arts, Mathematics, and Science is intended to illustrate some of the ways in which Applied Learning may be integrated with the subject areas and may provide a vehicle for learning in the disciplines. These references are shown only for Standard 1, Problem Solving.

The cross-referencing among the Applied Learning standards is intended to illustrate some of the ways in which a single project can provide a vehicle for demonstrating achievement of a number of Applied Learning. It is intended that Applied Learning tools and techniques be developed in conjunction with problem solving projects, rather than as isolated skills.

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Work Sample & Commentary: *Caring for Your Campus Lawn*

1 Reading	2 Writing	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech. Tools & Techniques	4 Learning & Self-mgmt. Tools & Techniques	5 Tools & Techniques for Working With Others

Applied Learning

The work presented from this project is not a comprehensive record of all work done as part of the project. This is partly because the project was not done with a view to providing evidence of these standards and partly because it would be neither reasonable nor appropriate to ask students to keep detailed written records of every aspect of every project. This would defeat part of the purpose of Applied Learning which is for students to learn from projects that have strong links to the world of work. Some of these standards better lend themselves to assessment through observation and other less formal methods than through written work.

Accordingly, the range and depth of evidence on which to base commentary related to the standards varies throughout this work sample.

Applied Learning required by the task

Chemistry students were asked to determine the most effective, economical, and environmentally safe grass fertilizer for the school district. The students were to produce an analytical report with detailed procedures and conclusions and to make a recommendation to the school district's Grounds and Maintenance Department.

Circumstances of performance

The students were given seven weeks to complete the project. They were responsible for all arrangements, such as making contacts with outside resources and obtaining permissions needed to complete the plan (see **Item A**). Class time was used to visit other campuses for soil collection, and time outside the school day was also used to complete various parts of the project. Students divided into groups with specific tasks to complete, that assisted other components of the project plan. The school district's grounds and maintenance director worked closely with the class during the project both as an advisor and as a client who would benefit from the research conducted by the class. The teacher facilitated the project and assisted the students as a resource person. Much of the work was completed as a practical.

This project gave students the opportunity to provide evidence related to the following Applied Learning standards:

Standard 1, Problem Solving—improving a system;

Standard 2, Communication Tools and Techniques—prepares a formal written proposal or report;

Standard 5, Tools and Techniques for Working With Others—participates in self-directed work teams; completes a project in response to a commission from a client.

The content of the project provides evidence for the quality of work expected for the following Science standard:

Standard 4, Scientific Connections and Applications.

Problem Solving—Improving a System

The student troubleshoots problems in the operation of a system in need of repair or devises and tests ways of improving the effectiveness of a system in operation; that is, the student:

- **explains the management and structure of the system in terms of its:**
  - **logic, sequences, and control;**
  - **impact;**
  - **operating principles, that is, the mathematical, scientific and/or organizational principles underlying the system;**
- **analyzes the design and management of the system, taking account of its functional, aesthetic, social, environmental, and commercial requirements, as appropriate, and using a relevant kind of modeling and systems analysis;**
- **evaluates the operation of the system using qualitative methods and/or quantitative measurements of performance;**
- **adapts techniques to control and manage the system in order to improve its performance by:**
- **identifying, testing, and adjusting sub-systems;**
- **developing and testing strategies to optimize performance.**

The students investigated the requirements for maintenance of campus lawns in the school district in order to arrive at recommendations to improve the effectiveness and efficiency of existing operations. The project documentation provides evidence that the students:

- ▲ developed a procedure for undertaking the project (**Items A** and **B**);
- ▲ studied the scientific principles underlying the maintenance system (**Items C, D, E,** and **G**);
- ▲ analyzed the design and management of the system, especially with regard to environmental requirements and cost analysis (**Items C, D, E, F,** and **G**);
- ▲ evaluated the system using quantitative measures (**Items C, D, E, F,** and **G**);
- ▲ made recommendations for improved techniques for managing the system based on analysis of fertilizers (**Item H**).

The students submitted their report to the Director of the Grounds and Maintenance Department and produced a set of procedures for revised practices in lawn maintenance to be used by building custodians, which was published under the Director's signature (see **Item I**).

This project illustrates an appropriate task for the high school level. Its scope extended beyond the school and immediate community of the students. It involved consideration of a range of factors including implications for cost. Finally, the project led to changes in practice. See the discussion below for commentary on the quality of the work in relation to the Science Standards.

Item A

To: Mr. , Principal
From: Mr. Period 1 Chemistry IB Class
Date: April 22, 1992
Subject: Proposal for funds for Applied Learning Project

For the next four to six weeks , our class is working on an Applied Learning Project called "The Chemistry of Soil and Fertilizers." This research is a part of Superintendent C^3 Project. The C^3 Partnership not only addresses workplace readiness but also prepares students for success in higher education. The anticipated products of the C^3 Project are a higher graduation rate, a practical alliance of schools and businesses linking the classroom with the world of work, and students who are better prepared to compete for entry-level jobs and to successfully complete college.

The purpose of our project is to determine the most effective, economical, and environmentally safe grass fertilizer for the Fort Worth Independent School District. The class will produce an analytical report with detailed procedures, conclusions, and recommendations for the Fort Worth Independent School District Grounds and Maintenance Department. The Grounds and Maintence Department will use the recommendations for future orders of fertilizer for the district.

The following is a list of the sequence of events to complete the project:

1. Prepare a basic project plan that will include projected costs and a research time table.
2. Prepare a proposal for submission to the principal (or other appropriate resources) requesting the necessary funds for the project.
3. Write to the Grounds and Maintenance Department of the school district requesting information on current fertilizing practices.
4. Write letters to plant nurseries and fertilizer companies requesting information on types of fertilizers and their percent compositions.
5. Interview a plant specialist to get ideas and gather information on grass types and fertilizers.
6. Research the basic grass types for the Fort Worth I.S.D.
7. Research the fertilizer requirements for different grasses on the school grounds.
8. Research the price, percent composition, and environmental safety of various brands of commercial fertilizers.
9. Based on our findings, we will determine the most effective, economical, and environmentally safe fertilizer for the school district campuses.
10. Write a letter to the Grounds Department either congratulating them on their choice of fertilizer or recommending a change in fertilizer.
11. Log all our efforts and produce a manual so that other students can monitor and/or replicate our efforts.

In order to complete this research, funds are needed. Our class has agreed that $100 will be sufficient to begin this important and worthwhile project. Please consider this proposal and help us obtain these necessary funds. A prompt response and your cooperation are greatly needed and appreciated.

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Item B

TIME TABLE

April 6 - April 10 Formed groups, study chemistry packet, call FWISD about current use of fertilizer, notes from parents, talk to Mr. about the project.

Data/Control Group - Worked on proposal for money. Also typed a letter for the soil testing group. Set up folder and a list of all the groups.

Research Group - Made phone calls around to the various groundsmen. Read through Texas Master Gardner Hanbook, and other books for information. They also compared the A&M and chemistry packet for differences.

Soil Tester Group - Looked up varios schools and decided what schools to go to. Called and got permission to come out to campuses. Called Nursery and asked about how to test the soil.

Interviewers ($) AT&T - Made phone calls. Got results from the different nurseries. Invited guest speaker. Wrote out questions to ask.

April 13 - April 16

Data/Control Group - Typed letter for money proposal. Typed a request letter for the Research group. Edited the letters and typed them up and sent them off.

Research Group - Recieved answeres from Nursery. Recieved information from . Made questions to ask. Planned questions for . Made phone calls. Wrote a letter. Went to thelibrary for more information. Recieved a letter from

Soil Testers Group - Called schools to get permission. Planned to get soil samples but was put on hold. Went to the library.

Interviewers (&) AT&T - Called again to set up date. Made more phone calls to different organizations. Made questions for FWISD representative. Wanted to see if other places would but there were no responses. Jason brought camera and taped different groups working.

April 20 - April 24

Data/Control Group - Our group took notes from the guest speaker. Wrote two thank you letters, one to for visiting our class and the other to for approving our proposal.

Research Group - Looked over information USDA sent. Made phone calls. Had vrsitor . Took notes. Found info. about organic fert. Wrote a paper about FWISD. Watched a tape to make sure facts were correct.

Soil Testers - Gathered soil from 4 different schools.

Interviewers (AT & T) - Made phone calls. Took notes over . Made a list of all the people called.

April 27 - May 1

Data/Control Groups - We typed reports and letters and edited the reports and letters. Several groups went out to measure the square feet of different schools. We sent out most of the letters we had to type.

Research - Edited letter and made changes for Stacy to type. Also, called to find out about measuring lawns. He brought out his measure. Chose schools to measure. Received information. Went to certain schools and measured lawns.

Soil Testers - Got soil samples and took picture of schools and them working. Began testing the soil samples. Got results from testing the soil but they all came out the same.

Interviewers (AT&T) - Organized the notebook and went to measure the schools that were chosen. Also, collected money. Made phone calls to ask about prices of fertilizer.

May 4 - May 8

Data/Control Group - Made phone calls to get directions to three schools. Some of the groups went to measure the sq. footage of school campus front lawns. Typed letters and reports. Trying to bring project to a close.

Research - Went to schools to measure lawns of school campuses. Made phone calls. Compared organic to inorganice prices. Started working on phamphlet. Looked over two handbooks for more information.

Soil Testers - Tested soil. Tried one soil test which didn't do so well. Then they got another more complicated soil testing kit after that failed, finally ended up sending soil samples to Texas A & M. Currently awaiting results.

Interviewers (AT & T) - Made phone calls.

May 11 - May 15

Data/Control Group - Started writing paper for journal. Typed out the averages of the schools front lawns. Typed testing procedures, safety, cleaning, and preparing soil samples. Worked on pamphlet. Wrote thank you letter to Dr.

Research - Called to get info. on organic vs. inorganic. Called for prices, compared prices, helped come up with conclusion.

Soil Testers - Received soil testing results from A&M. Analyzed data and made data table. Wrote conclusion.

Interviewers (AT&T) - Talked to from Tarrant County Extension Service. Talked to from Dallas who refused to speak to class. Contacted

May 18 - May 22

Data/Control Group - Finished summary. Finished pamphlet. Sent pamphlet to all Fort Worth schools. Put pictures in notebook.

Research - Finished summary. Presented results to with pamphlet.

Soil Testers - Analyzed data and proofed summary.

Interviewers (AT & T) - Contacted

French students who plan to qualify fo the Baccalauréat Professionnel must know how to do the following in orde to be prepared for the world of work:

- to present themselves, say what they have already accomplished and wh they know, exhibit their projects;
- to seek information and explanation
- to maintain and follow discussions;
- to read documents, records, service notes, directions, safety notices, etc.;
- to gather information, conduct research, conduct surveys;
- to take notes, organize them, and use them to make a summary;
- to consult, analyze, and critique documents;
- to record experiences and assemble them for progress reports, exhibitions a portfolio, or a report.

Baccalauréat Professionnel: Enseignments généreaux, p. 12.

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Work Sample & Commentary: *Caring for Your Campus Lawn* continued

1 Reading	2 Writing	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Experiments & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1	2	3 Information Tech. Tools & Techniques	4 Learning & Self-mgmt. Tools & Techniques	5

Applied Learning

Item C

FWISD Grass Type

Bermudagrass

Bermudagrass is a low, creeping grass that grows year round. In the United States bermuda grass is a valuable lawn and pasture grass throughout the southern states.

Bermudagrass should be mowed at 1 1/4 inches every 5 to 6 days. Leaving grass clippings on the lawn contributes valuable nutrients to the soil.

Watering thoroughly and infrequently is best. During the summer, lawns require about 1 inch of water every 5 to 6 days. Watering in early morning is best because less water is lost in evaporation.

Bermudagrass requires 4 to 6 pounds of nitrogen per year to maintain color and density. Apply 2-3 pounds of fertilizer per 1,000 sq. ft. Apply the fertilizer at the following intervals: April 15, June 1, July 15, Sept. 1. By using a fertilizer containing sulfur-coated urea or ureaformaldhyde, a slow and even growth can be attained.

Current FWISD Fertilizing Practices

Athletic Field

During playing seasons, athletic fields in the FWISD grow turf grass. After the baseball season is over, fescue grass is grown. The current practices call for the fields to be fertilized four times during the warm season and twice during the cold season.

Front Lawns

The most common grass found on the FWISD campuses is bermuda. The front lawn fertilizing practices are as follows:

6 lbs. of Nitrogen per 1000 sq. ft. per year
fertilize with 15-5-10 four times a year starting after the last freeze,
approximately March 15
other treatments follow eight weeks apart (5/15, 7/15, 9/15)
- 1 1/2 lbs. of Nitrogen is used each time

The FWISD uses ammonical based fertilizer for economical reasons. The ammonical based fertilizer runs about $175.00 per ton, while organic fertilizers cost between $275.00 and $325.00 a ton. Because of the amount of land needing to be fertilized and the expense of organic fertilizers, current practices continue to use ammonical based fertilizers.

Size of the Front Lawns in Fort Worth ISD

High Schools

1. Southwest High School	41,045.5
2. Arlington Heights	8,837
3. Western Hills	15,788
Average	21,890 * 12 high schools => 262,680 sq. ft.

Middle Schools

1. Leonard	6,831
2. McLean	21,780
3. Rosemont	34,180
4. Wedgwood	6,877
Average	17,417 * 19 middle schools => 330,923 sq. ft.

Elementary Schools

1. Western Hills	8,070
2. Tanglewood	4,000
3. Bruce Shuksey	3,966
4. West Cliff	4,364
5. Ridgles Hills	3,640
6. Hubbard Heights	4,601
7. West Park	12,321
8. JT Stevens	26,445
9. Woodway	37,318
10. Westcreek	11,520
11. Greenbriar	13,230
12. South Hills	18,920
13. South Hi Mount	12,581
14. Glen Park	10,450
Average	12,243 * 68 elementary => 832,524 sq. ft.

Total of 1,426,127 sq.ft

* 1 acre has 43,560 sq.ft. 1,426,127/43,560=> 33 acres for theFort Worth ISD

SOIL TESTING RESULTS
Ph, NITROGEN, PHOSPHORUS, AND POTASSIUM

SCHOOL	Ph	N	P	K
1. Arlington Heights H.S.	8.1	Low	Very High	Very High
2. Kirkpatrick Elementary	7.9	Very High	Very High	Very High
3. Meachum M. S.	7.9	Moderate	Very High	Very High
4. Northside H.S.	8.0	Moderate	Very High	Very High
5. South Hi Mount Elementary	7.8	High	Very High	Very High
6. Simpling M.S.	7.9	Very High	Very High	Very High
7. Forest Hill Elementary	8.0	Low	Very High	Very High
8. Forest Oak M.S.	7.6	Very High	Very High	Very High
9. Southwest H.S.	7.3	High	Very High	Very High
10. Tanglewood Elementary	8.0	High	Very High	Very High
11. Wedgwood M.S.	7.7	Very High	Very High	Very High
12. O.D.Wyatt H.S.	8.0	Low	Very High	Very High

SOIL TESTING OBSERVATIONS

Out of the 12 schools tested over the F.W.I.S.D., we found that all of the schools were abundant in phosphorus and potassium. Three of the schools were low in nitrogen, two were moderate, three were high, and four were very high in nitrogen.

The pH level ranged from 7.3 to 8.1 (7.3 lower, 8.1 higher). We found that five of the schools had a pH level of 8 or more. The seven remaining schools had a pH level of 7.3 to 7.9.

SAFETY

The poly bag of capsules should be returned to the storage chamber of the appropriate comparator after it has been washed and dried. Fit the caps on each comparator and make sure the color charts are in place. Replace all the components back into the package. The slide blister has been especially designed to be reused as a storage container. Store your kit indoors in clean, dry conditions, as you would store household cleaners. Keep out of the reach of children.

CLEANING

Dispose of the test solutions by rinsing it down the sink. Empty gelatin capsules should be disposed of immediately with household waste. Remove the color charts. Wash the comparator and caps in warm, soapy water immediately after each use. Make sure any sediment or color staining is removed. Rinse well and dry. Replace the color chart on the appropriate comparators.

PREPARING SOIL SAMPLES

For lawns, annuals or plants, take the soil sample from about 2 - 3 inches below the surface. For perennials, especially shrubs, vegetables and fruits, the sample should be from 4 inches deep. Avoid touching the soil with your hands. Place the soil in one of the containers. Break the sample up with the trowel or spoon and allow it to dry out naturally. This is not essential, however, it makes working with the sample easier. Remove any small stones, organic material such as grass, weeds or roots, or hard particles of lime. Then, crumble the sample finely and mix it thoroughly.

Test different areas of your soil, as it may differ according to past cultivation, underlying soil difference of a local condition. It is preferable to make individual tests on several samples from different areas, than to make the samples together.

TESTING PROCEDURES

1. Fill the second container with 1 part of soil sample and 5 parts water.
2. Thoroughly shake or stir the soil and water together for at least one minute and then allow the mixture to settle out. Wait 10 minutes, longer if possible. The time for the mixture to settle will vary according to the type of soil you have. Fine clay soil will take longer than coarse sandy soil. The clarity of the solution will also vary from virtually clear to cloudy. Cloudiness will not affect the accuracy of the test.
3. Select the appropriate comp-arator for the test you wish to make. Remove the cap and take out the poly bag of capsules which should be the same color as the cap. Make sure the color chart (film) is in place and avoid interchanging color charts between comparators.
4. Using the dropper provided, fill the test and reference chambers, to the fill mark on the chart, with solution from your soil sample. Avoid disturbing the sediment - transfer only liquid.
5. Fill the storage chamber to the same level with clean tap water.
6. Remove one of the appropriate colored capsules from its poly bag. Carefulley separate the two halves and pour the powder into the test chamber.
7. Fit the cap onto the comparator, making sure it is seated properly and caps tightly. Shake thoroughly.
8. Allow the color to develop in the test chamber for the following times: pH - 1 min.; Nitrogen - 10 mins., Phosphorus and Potash - 5 mins. Before taking a reading, invert the comparator several times to obtain a uniform color, then compare the color of the solution in the test chamber to the color chart.

Organic vs. Inorganic

Inorganic	Organic
- cheaper	- much more expensive
- soil polutants	better for soil
- more readily available	- harder to get
- easier to apply	- harder to apply
- need less per 1000 sq. feet	- need more per 1000 sq. feet
- contains lots of salt and nitrates that kill or repel beneficial organisms in soil	- low levels of salts and nitrates, which kill or repel beneficial organisms in soil
- does nothing for resistance to diseases	- increases resistance to most diseases
- decomposes slowly and can enter water system and harm us	-decomposes easily

* inorganic
33 acres -- 7 lbs./1000 sq feet -- apply 4 times a year=> $ 3,000

* organic
33 acres -- 40 lbs./1000sq feet -- apply 3 times a year=> $ 10,225

total difference is $ 7,225 less for inorganic

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Communication Tools and Techniques

The student prepares a formal written proposal or report to a community organization or business; that is, the student:

- **organizes the information in the proposal or report in a logical way appropriate to its purpose;**
- **produces the proposal or report in a format similar to that used in professionally produced documents for a similar purpose and audience.**

The project led to the production of a formal written report to the Director of the Grounds and Maintenance Department for the school district **(Item H)**. The report clearly sets out the procedures the students followed and their findings. It adopts a memorandum format appropriate to communicating a technical report of this sort, particularly one produced effectively in-house, and it is written in a style consistent with a memorandum. The students also chose the format of a memorandum for the pamphlet they prepared to communicate the project findings to grounds keepers, again an appropriate format **(Item I)**. In this document, however, they adjust the style, making it less discursive and more direct. This is appropriate, given the purpose of the pamphlet to provide directions. The information is set out clearly and logically, consistent with its purpose.

These documents provide evidence for the quality of work expected.

These documents are also presented as finished work, as is appropriate to their purposes and audiences. The polish of these documents can be compared with the errors that appear in the Proposal to the Principal, where the space should be eliminated between "weeks" and the comma and "maintence" should be "maintenance," and with errors in some of the students' working documents.

Tools and Techniques for Working With Others

The student participates in the establishment and operation of self-directed work teams; that is, the student:

- **identifies the range of knowledge and skills required for a given project;**
- **defines roles and shares responsibilities among team members;**
- **sets objectives and time frames for the work to be completed;**
- **establishes processes for group decision making;**
- **reviews progress and makes adjustments as required.**

The time table **(Item B)** indicates that students shared the load of work required for the project by forming groups, each with responsibility for a specific component of the project. However, the available evidence does not allow for commentary on the effectiveness of the work processes the students adopted.

The student completes a task in response to a commission from a client; that is, the student:

- **negotiates with the client to arrive at a plan for meeting the client's needs that is acceptable to the client, achievable within available resources, and includes agreed-upon criteria for successful completion;**
- **monitors client satisfaction with the work in progress and makes adjustments accordingly;**
- **evaluates the result in terms of the negotiated plan and the client's evaluation of the result.**

The client for this work was the Director of the Grounds and Maintenance Department for the school system. **Item I** indicates that there was communication between the students and the Director during the course of the project, but there is no evidence to allow for commentary on the negotiation with him to arrive at a plan or on the monitoring of his satisfaction with the work in progress. The pamphlet the students wrote for grounds keepers, setting out procedures for lawn maintenance, appears under the Director's signature, which suggests that he was satisfied with the students' report and accepted their recommendations.

Item D

Dear Dr.

Thank you for helping our class today on the telephone! We greatly appreciate your time and expertise. Our project objective is to determine the most effective, economical, and environmentally safe grass fertilizer for the Fort Worth I.S.D. Our plans are to produce an analytical report with detailed procedures and conclusions and a recommendation report for the Fort Worth I.S.D. Grounds and Maintenance Department. We only have 2 weeks to complete our research!

Please test these 12 soil samples for pH, N, P, and K. We are only concerned with the regular analysis. Thank you for running these reports at no charge. Please call us at between 8:15 and 9:00 a.m. as soon as you have the results. Also, please send us the written reports with information on how to interpret the data.

Sincerely,

Item E

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Work Sample & Commentary: *Caring for Your Campus Lawn* continued

1 Reading	2 Writing	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech. Tools & Techniques	4 Learning & Self-mgmt. Tools & Techniques	5 Tools & Techniques for Working With Others

Applied Learning

Science

The students gathered and analyzed data from a variety of sources and made recommendations based on this evidence. The scope of work outlined in the "Letter to the Principal" shows all of the components of a design investigation, as set out under Standard 8, Scientific Investigation. The conclusions presented in the memo to the Grounds and Maintenance Department are consistent with the data presented, but since the description of the data analysis is abbreviated in this format, it is not possible to determine whether or how students used all of the data that they gathered.

Analyzing the fertilizer requirements for different types of grass in different soil samples is a task that brings together information across the sciences. The recommendation is presented in the memo: "The soil testing results revealed that most of the Fort Worth I.S.D. soil is in good shape. Some of the lawns need nitrogen, but all that were tested are high in phosphorous and potassium and the pH level is good also. After analyzing this data, a 15-5-10 inorganic fertilizer applied at 7 lbs. per 1,000 square feet about four times a year is recommended."

Conceptual understanding in Science

Physical Sciences Concepts

The report of "Soil Testing Results" shows attention to concentrations of H+, nitrogen, phosphorous, and potassium. It is not stated in the soil testing summary, "Soil Testing Observations," whether it is necessary to take these differences in concentration into account in recommending one or more than one fertilizer treatment, nor is there evidence of conceptual understanding of pH.

Life Sciences Concepts

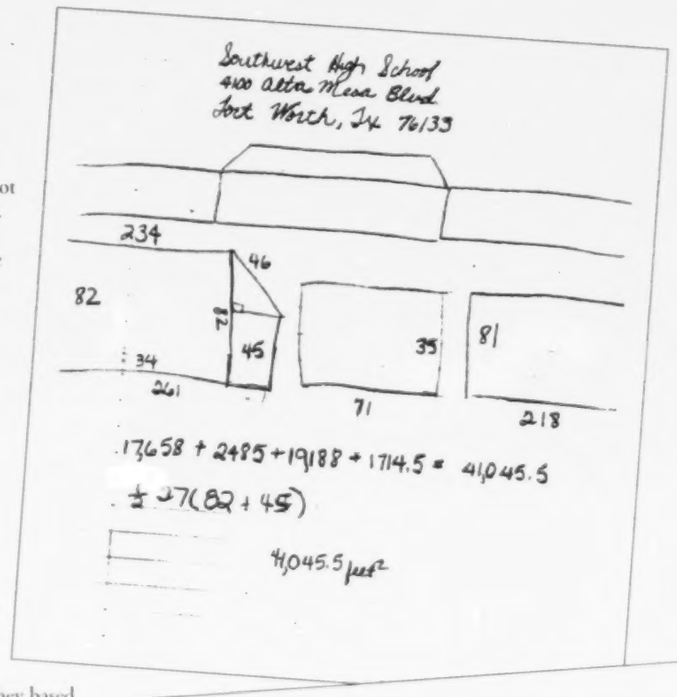
The pages entitled "FWISD Grass Type" and "Current FWISD Fertilizing Practices" show attention to the different requirements of different types of grass, though the requirements of fescue grass are not stated. Therefore, it is not possible to tell if the different types are sufficiently similar to Bermuda grass to recommend one fertilizer year round or to differentiate the treatment by the kind of grass on the fields. Further, Bermuda grass benefits from a fertilizer containing sulfur-coated urea or urea formaldehyde, an organic compound. The needs of the predominant type of grass, Bermuda, are not part of the organic vs. inorganic analysis presented on the page entitled "Organic vs. Inorganic."

Additional evidence related to Life Sciences Concepts is presented on the page "Caring for Your Campus Lawn," which gives mowing and watering instructions. Because students interviewed peopled experienced in lawn care, it is likely that they based their recommendations on the experts' suggestions. The students provide an explanation for watering procedures but not for mowing procedures. Therefore, it is not clear whether they understood how the mowing procedures relate to grass growth or whether they simply adopted rules of thumb based on experience.

Earth Sciences Concepts

Several soil samples were tested. Because the students used kits and sent samples out to a laboratory, the extent to which they understood the tests is not evident.

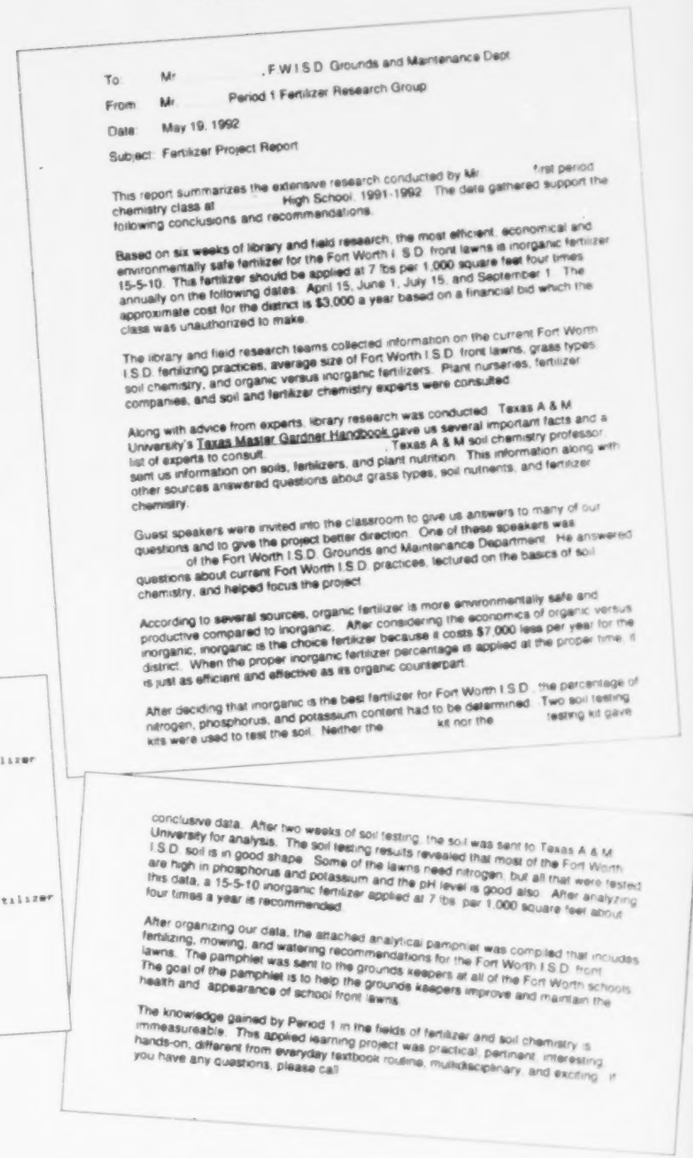
Item F



Item G

Inorganic
(1,426,127 sq.ft./1000 sq.ft.) @ 7 lbs. fertilizer=> 9982.89 lbs.fertilizer
(9982.89 lbs.fertilizer)/2000 lbs. => 5 tons of fertilizer
5 tons at $150.00 is $750.00
4 times a year @ $750.00 => 3,000.00
Organic
(1,426,127 sq.ft./2500 sq.ft.)@ 40 lbs. fertilizer => 22,810 lbs. fertilizer
22,810 lbs./2000 lbs. => 11.4 tons
11.4 tons at $300.00 is $3422.70
3 times a year @ $3422.70 => $10,268.11

Item H


To: Mr , F.W.I.S.D. Grounds and Maintenance Dept

From: Mr Period 1 Fertilizer Research Group

Date: May 19, 1992

Subject: Fertilizer Project Report

This report summarizes the extensive research conducted by Mr first period chemistry class at High School, 1991-1992. The data gathered support the following conclusions and recommendations.

Based on six weeks of library and field research, the most efficient, economical and environmentally safe fertilizer for the Fort Worth I.S.D. front lawns is inorganic fertilizer 15-5-10. This fertilizer should be applied at 7 lbs per 1,000 square feet four times annually on the following dates: April 15, June 1, July 15, and September 1. The approximate cost for the district is $3,000 a year based on a financial bid which the class was unauthorized to make.

The library and field research teams collected information on the current Fort Worth I.S.D. fertilizing practices, average size of Fort Worth I.S.D. front lawns, grass types, soil chemistry, and organic versus inorganic fertilizers. Plant nurseries, fertilizer companies, and soil and fertilizer chemistry experts were consulted.

Along with advice from experts, library research was conducted. Texas A & M University's Texas Master Gardner Handbook gave us several important facts and a list of experts to consult. , Texas A & M soil chemistry professor sent us information on soils, fertilizers, and plant nutrition. This information along with other sources answered questions about grass types, soil nutrients, and fertilizer chemistry.

Guest speakers were invited into the classroom to give us answers to many of our questions and to give the project better direction. One of these speakers was of the Fort Worth I.S.D. Grounds and Maintenance Department. He answered questions about current Fort Worth I.S.D. practices, lectured on the basics of soil chemistry, and helped focus the project.

According to several sources, organic fertilizer is more environmentally safe and productive compared to inorganic. After considering the economics of organic versus inorganic, inorganic is the choice fertilizer because it costs $7,000 less per year for the district. When the proper inorganic fertilizer percentage is applied at the proper time, it is just as efficient and effective as its organic counterpart.

After deciding that inorganic is the best fertilizer for Fort Worth I.S.D., the percentage of nitrogen, phosphorus, and potassium content had to be determined. Two soil testing kits were used to test the soil. Neither the kit nor the testing kit gave conclusive data. After two weeks of soil testing, the soil was sent to Texas A & M University for analysis. The soil testing results revealed that most of the Fort Worth I.S.D. soil is in good shape. Some of the lawns need nitrogen, but all that were tested are high in phosphorus and potassium and the pH level is good also. After analyzing this data, a 15-5-10 inorganic fertilizer applied at 7 lbs. per 1,000 square feet about four times a year is recommended.

After organizing our data, the attached analytical pamphlet was compiled that includes fertilizing, mowing, and watering recommendations for the Fort Worth I.S.D. front lawns. The pamphlet was sent to the grounds keepers at all of the Fort Worth schools. The goal of the pamphlet is to help the grounds keepers improve and maintain the health and appearance of school front lawns.

The knowledge gained by Period 1 in the fields of fertilizer and soil chemistry is immeasureable. This applied learning project was practical, pertinent, interesting, hands-on, different from everyday textbook routine, multidisciplinary, and exciting. If you have any questions, please call

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Scientific Connections and Applications

A cost/benefit analysis is clearly illustrated on the page titled "Organic vs. Inorganic." While the omission of the requirements of Bermuda grass is a flaw in the presentation, many important variables are contrasted. The generally good condition of the soil and the vast differences in cost would lead to the same conclusion.

In summary, the evidence presented is not compelling for Standards 1, 2, or 3 but very solid for Standard 4, Scientific Connections and Applications.

Scientific Tools and Technologies

The students' work provides evidence for part of the standard for Scientific Tools and Technologies—analyzes data, taking steps to limit observer and sample biases, using concepts and skills from the mathematics standards for high school. Part of the cost/benefit analysis for different fertilizer types was premised on knowing the total acreage to be fertilized. The diagram of Southwest High School shows how the area of the lawn was determined for that school. The page titled "Size of the Front Lawns in Fort Worth ISD" shows that the lawn area for a sample of schools at each level was determined and the total area for all schools at the level was estimated by multiplying the number of schools by the average area. In principle, this is a good method for getting an estimate. The method for taking the sample is not stated, however, and given the ranges of the areas in the sample, it is not clear that the sample was sufficient. Among the high schools, for example, the largest area, (Southwest at over 41,000 square feet) is nearly five times the area of the smallest (Arlington Heights at 8,837 square feet). Is there something about the school with a small lawn, which does not have enough room for a football or baseball field, that makes it an outlier, or is the large lawn the exception? The range of areas at the elementary level is also great, e.g., Woodway's area is ten times the area of Ridglea Hills. Are newer schools getting larger or smaller lawns or are there alternative recreation areas adjacent to the schools with small lawns? When the range of the data is so great, it is necessary to determine whether there is a similar distribution in the population before using the sample to produce an estimate for the population. It is possible that one third of the high schools, half of the middle schools, and a smaller proportion of the elementary schools have large lawns, but these possibilities should be noted in the presentation of the data. Without explicit discussion of this point, the estimate for the total lawn area must be considered lacking from a statistical point of view.

A final, less substantial mathematical concern is the use of the exact figure, 1,426,127 square feet, given its derivation from the sample. Rounding it to 33 acres is preferable, as used on the page titled "Organic vs. Inorganic." Using exact figures in the earlier calculations is inaccurate.

Going beyond

Many of the components set out under the description of Standard 8, Scientific Investigation, are present. The question studied, the procedures, the collection and recording of data, and the acknowledgments of sources are evidence for the quality of work expected at the high school level. There are enough questions about the analysis of the soils data leading to the recommendation of fertilizer and the use of the sample to determine the estimate of the total acreage, however, to withhold judgment about the work as a scientific investigation until the missing explanations can be provided. If the work were revised to show that the data led to the conclusions and that the sample of schools represents the population of schools, it would illustrate the Scientific Investigation standard.

Item I

Dear Mr.

We, the students of Mr. _____ first period class, would like to thank you for all the time and effort you have put forth into the C^3 project. Enclosed is a copy of the fertilizer pamphlet we have comprised for your file. Thank you for all of your help and information. We couldn't have done it without you!

Sincerely,

Item J

NOTICE!!!

TO: Grounds Keeper

FROM: F.W.I.S.D. Grounds and Maintenance Dept.

DATE: Spring/Summer 1992

SUBJECT: Front Lawn Care

PLEASE POST

CARING FOR YOUR CAMPUS LAWN

For a well maintained lawn follow these quick and easy steps!

FERTILIZATION

1. Measure the square footage of the lawn.
   To measure the square footage, multiply A and B together.

   A — To get A & B, simply walk off the number of feet — B

   Then, divide the answer of A and B by 1,000.
   Next, take the answer from above and multiply by 7. This gives you the amount of fertilizer in pounds for each time that you fertilize.
2. Fertilize on these dates for best results: *April 15, June 1, July 15, September 1.*
3. Use 15-5-10 percentage fertilizer.
4. Requisition fertilizer from the F.W.I.S.D. warehouse.

MOWING

1. Mow the lawn at 2 inches weekly or when grass blade reaches one-third mowing height.
2. Leave grass clippings on the lawn--Don't Bag It!

WATERING

1. Water in early morning so less water is lost to evaporation.
2. Water thoroughly and infrequently making sure that in the summer the lawn gets 1 inch of water every week.

If you have any questions, please call _____ **at** _____

This information is based on extensive research done in Mr. _____ *first period chemistry class at* _____ *High School, 1991-1992.*

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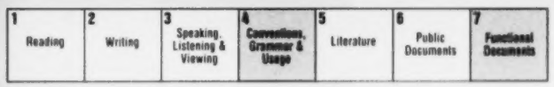
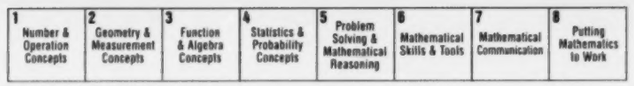
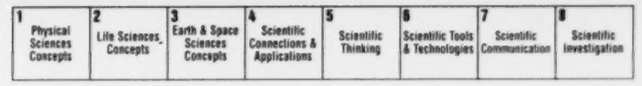
Work Sample & Commentary: *Who? Me? Pollute?*



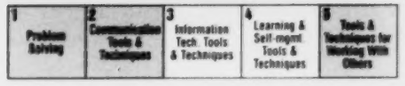
English Language Arts


1 Number & Operation Concepts
2 Geometry & Measurement Concepts
3 Function & Algebra Concepts
4 Statistics & Probability Concepts
5 Problem Solving & Mathematical Reasoning
6 Mathematical Skills & Tools
7 Mathematical Communication
8 Putting Mathematics to Work

Mathematics


1 Physical Sciences Concepts
2 Life Sciences Concepts
3 Earth & Space Sciences Concepts
4 Scientific Connections & Applications
5 Scientific Thinking
6 Scientific Tools & Technologies
7 Scientific Communication
8 Scientific Investigation

Science


1 Problem Solving
2 Communication Tools & Techniques
3 Information Tech. Tools & Techniques
4 Learning & Self-mgmt Tools & Techniques
5 Tools & Techniques for Working With Others

Applied Learning

The work presented from this project is not a comprehensive record of all work done as part of the project. This is partly because the project was not done with a view to providing evidence of these standards and partly because it would be neither reasonable nor appropriate to ask students to keep detailed written records of every aspect of every project. This would defeat part of the purpose of Applied Learning which is for students to learn from projects that have strong links to the world of work. Some of these standards better lend themselves to assessment through observation and other less formal methods than through written work.

Accordingly, the range and depth of evidence on which to base commentary related to the standards varies throughout this work sample.

Applied Learning required by the task

Chemistry students were asked to study a local lake to determine if the lake was physically, biologically, and/or chemically contaminated. The students were asked to devise a plan to clean up the lake or to keep it clean and to educate surrounding residents about how they could prevent further contamination.

Circumstances of performance

Students were given four weeks to complete the task. A couple of days were spent planning the project and obtaining approval from the principal to work on it. Class time was spent doing fieldwork at the lake. Experts from the local water treatment plant and from laboratories that perform chemical analysis were invited to speak to the class about water pollution. Students were responsible for contacting the speakers, obtaining permission, and setting up the actual visit. Data from the lake water were analyzed both by students and a local testing company. The teacher acted as a facilitator and a resource to the students.

This project gave students the opportunity to provide evidence related to parts of the following standards:

Applied Learning Standard 1, Problem Solving—improving a system;

Applied Learning Standard 2, Communication Tools and Techniques—prepares a formal written proposal or report;

Applied Learning Standard 5, Tools and Techniques for Working with Others—participates in self-directed work teams;

English Language Arts Standard 4, Conventions, Grammar, and Usage of the English Language—uses appropriate conventions;

English Language Arts Standard 7, Functional Documents—produces a functional document.

Problem Solving—Improving a System

The student troubleshoots problems in the operation of a system in need of repair or devises and tests ways of improving the effectiveness of a system in operation; that is, the student:

- **explains the management and structure of the system in terms of its:**
  - **logic, sequences, and control;**
  - **impact;**
  - **operating principles, that is, the mathematical, scientific and/or organizational principles underlying the system;**
- **analyzes the design and management of the system, taking account of its functional, aesthetic, social, environmental, and commercial requirements, as appropriate, and using a relevant kind of modeling and systems analysis;**
- **evaluates the operation of the system using qualitative methods and/or quantitative measurements of performance;**
- **adapts techniques to control and manage the system in order to improve its performance by:**
  - **identifying, testing, and adjusting sub-systems;**
  - **developing and testing strategies to optimize performance.**

The project documentation provides evidence that the students:

- ▲ established a plan for the project shown in the proposal to the principal (**Item A**) after exploring possibilities (**Items B** and **C**) both in relation to the scientific aspects of the investigation and the demands of interacting with the community with regard to the outcomes of the project;
- ▲ collected information from a variety of sources, including an invited speaker from the Water Department (**Items D** and **E**), fieldwork, and laboratory experiments (**Item F**), as part of establishing the scientific principles underlying the system. **Item G** records some of the students' findings;
- ▲ used experiments, a form of modeling, to analyze the system. The experiments included tests done both by the students and by a professional organization;
- ▲ used quantitative measures of water quality to evaluate the performance of the system;
- ▲ proposed strategies to improve the performance of the system in light of their research (**Items H** and **I**).

The final products of the project are recommendations to government officials and an informative pamphlet designed by students and delivered to residents living in the drainage area of the lake. City authorities erected signs at the lake in response to the students' request, and city crews were sent to clean up the litter at the lake site.

The project illustrates an appropriate task for the high school level. Its scope extended beyond the school and immediate community of the students. It involved consideration of a range of factors affecting the system. Finally, it led to changes in practice.

Communication Tools and Techniques

The student prepares a formal written proposal or report to a community organization or business; that is, the student:

- **organizes the information in the proposal or report in a logical way appropriate to its purpose;**
- **produces the proposal or report in a format similar to that used in professionally produced documents for a similar purpose and audience.**

The project led to the production of a formal written report to the Water Department (**Item H**). The report adopts a business letter format appropriate to communicating information of this sort. It summarizes the students' findings clearly and generally adopts an appropriate tone, although the deadline for response is expressed in a rather more imperative style than might be appropriate in this situation. It is unclear whether the students attached their class research report to the letter. It would have been desirable to append a report substantiating the recommendations set out in the letter. Material that could have been used to substantiate the recommendation appears in the work sample, as part of a report of the project as a whole. However, that report appears to have been written with a teacher or general audience in mind rather than tailored appropriately to the particular needs and interests of the Water Department. For example, the Water Department is referred to in the third person in the "Conclusion."

The students chose the format of a flyer for communicating their project findings to residents in the area surrounding the lake, again an appropriate format (**Item I**). In this document, however, they adjust the style, making it less discursive and more focused on communicating a small number of messages and establishing the credentials of the authors creating those messages. This is appropriate, given the purpose of the pamphlet. The information is set out clearly and logically, consistent with its purpose, and efforts have made to make the material eye catching.

The report to the Water Department and the flyer are finished writing produced for real purposes and audiences. One spelling error remains, however, in the flyer ("effects" should be "affects"). The spelling errors in the students' working documents do not detract from the purpose of the writing, which was to record research procedures and results. They would not be acceptable in finished writing.

Tools and Techniques for Working With Others

The student participates in the establishment and operation of self-directed work teams; that is, the student:

- **identifies the range of knowledge and skills required for a given project;**
- **defines roles and shares responsibilities among team members;**
- **sets objectives and time frames for the work to be completed;**
- **establishes processes for group decision making;**
- **reviews progress and makes adjustments as required.**

The students worked cooperatively to produce a single set of final products. However, the available evidence does not allow for commentary on the effectiveness of the work processes the students adopted.

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English Language Arts

Functional Documents

The student produces at least one functional document, appropriate to audience and purpose, in which the writer:

- **reports, organizes, and conveys information and ideas accurately;**
- **includes relevant narrative details, such as scenarios, definitions, examples;**
- **anticipates readers' problems, mistakes, and misunderstandings;**
- **uses a variety of formatting techniques, including headings, subordinate terms, foregrounding of main ideas, hierarchical structures, graphics, and color;**
- **establishes a persona that is consistent with the document's purpose;**
- **employs word choices that are consistent with the persona and appropriate for the intended audience.**

The work provides evidence that the student:

▲ conveys accurate information that addresses topics the audience needs to know, e.g., identifies the "we" authoring the letter ("Mr. _____'s fourth period Chemistry class"); provides a detailed statement of the purpose for writing ("We…are starting an Applied Learning Project"); identifies the area of study ("water contamination");

▲ indicates the scope of the project: "The sequence of events for the project is the following";

▲ anticipates reader problems, e.g., when asking for money, the letter identifies the fact that part of the money will go for a reusable item (the water testing kit); also, the letter ties the success of the project to "further(ing) our knowledge in chemistry," providing an additional impetus to approve funding;

▲ uses formatting techniques, e.g., numbered list of events and a variation on a block letter format;

▲ establishes a persona consistent with the document's purpose, e.g., addresses the principal as a reasonable person interested in learning ("Your approving this budget…will greatly further our knowledge in chemistry") and in community relations ("The purpose of our research is to study water contamination…in the _____ neighborhood" and "educate the surrounding residents");

▲ makes appropriate and sophisticated word choices: chooses strong, emotionally charged words (the word "contamination" instead of the less urgent "pollution"); places the project in a larger context ("as part of Superintendent ____'s C3 Project"); emphasizes community-based aspects of the project, e.g., the neighborhood location of the research project, the consultation with two city agencies and the development of a pamphlet for neighborhood distribution.

Conventions, Grammar, and Usage of the English Language

The student independently and habitually uses the appropriate conventions of the English language, including:

- **spelling;**
- **sentence construction;**
- **paragraph structure;**
- **punctuation;**
- **grammar;**
- **usage.**

The work provides evidence that the student:

▲ in almost error free writing, manages spelling, punctuation, and sentence and paragraph construction.

Item A

April 21, 1992

Dear Mr.

We, Mr. fourth period Chemistry class, are starting an Applied Learning Project as a part of Superintendent C3 Project. The purpose of our research project is to study water contamination, determine if Lake (located in the neighborhood) is chemically contaminated, devise a plan to clean it up or keep it clean, and educate the surrounding residents of how they can prevent further contamination.

The sequence of events for the project is the following:

1. Prepare a project plan that will include projected cost and a research time table.
2. Write a proposal to Mr. requesting necessary funds.
3. Call the Ft. Worth Water Department and the Parks and Recreation Center asking about information on water contamination.
4. Interview someone from the Water Department to find out the equipment necessary to evaluate the water contamination of Lake.
5. Order a water testing kit and any other necessary materials.
6. Obtain water samples needed for testing.
7. Test the water and evaluate the contaminants and probable causes of contamination.
8. Find out what we can do to help clean up or avoid any further chemical contamination.
9. Write up a report of all our findings and produce a pamphlet for the surrounding residents educating them on prevention of contamination.

The proposed budget for this project totals $ 395.00. This budget includes a water testing kit that will be used again in the years to come, fish and styrofoam for the "fish in the bottle" experiment, and paper to print our pamphlet for the surrounding community. Your approving this budget will be greatly appreciated and will greatly further our knowledge in chemistry.

Sincerely,

Item B

Notes- lake

Hydrocarbons big concern for F lake
- slicks on top of water (can freeze, oil, gasoline)

Investigate area around the lake
- look for visible evidence of trash, garbage, etc
- look at the vegetation around the lake to see if it looks brown (dying)
- herbicides do harm the water

- Suggest going door to door to ask how many people use or other lawn services.

* Look at topography map

* Storm water can contain hydrocarbons from cars that leak oil, etc onto the road

Set up an aquarium with water from Lake study their "reactions", if any.

"In the [Japanese secondary] school, proper guidance should be given, in conformity with the realities of the school and its region, to provide students with work experience so that they may appreciate the pleasure of working and creation and develop a desirable view of work and occupations."

Course of Study for Upper Secondary Schools in Japan, p. 1.

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Work Sample & Commentary: *Who? Me? Pollute?* continued

1 Reading	2 Writing	3 Speaking, Listening & Viewing	**4 Conventions, Grammar & Usage**	5 Literature	6 Public Documents	**7 Functional Documents**

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	**2 Communication Tools & Techniques**	3 Information Tech Tools & Techniques	4 Learning & Self-mgmt Tools & Techniques	**5 Tools & Techniques for Working With Others**

Applied Learning

Item C

Water Pollution
1) Is it polluted?
2) How can we clean it up?

- Project Plan
* objective
* Research time table
* kinds of groups

Audience
Park and Recreation Department) F W Water Dept.
Residents) Donations
let them know were legit

water pollution activists
Fisherman
Pet stores
Wildlife Dept

objective
The effects of chemicals on small fish and plant life
water pollution in lake make a pamphlet
to educate the neighborhood
The purpose of this project is to research water pollution and then determine if lake is polluted and if so devise a plan to clean it up.

what kind of journal are we going to keep?
Spiral notebook, regular size. different colors
Non-uniform

Item D

NOTES

4-16-92 Speaker FW Water Dept

What is pollution)
· The alteration of physical thermal biographical quality of a contaminate of that makes wastes dangerous.

Analysis – Climinate whether it is contaminated
- hard to test for
- Test for Fecal contamination using indicator organism Ecoli

Chemical characteristics of water
- Heavy metals
- Ammonia. Nitrite and Nitrate Level
- algae - to much kills fish
- Dissolved oxygen test at different times.

Heavy metals - lead but others are too difficult
- Sulfates
- Chlorides -
Ph 6-9 mostly &
1% of all water is fresh water & only a small % is contaminated

Item E

Dear Mr.

Thank you for taking time out of your busy schedule to talk to us about water quality. Your lecture on water contamination helped us to find out more about water pollution and what we can do to correct and/or prevent it from harming Lake.

We are excited about using your suggestions in order to determine if Lake is contaminated. Your speech was very helpful and informative and we greatly appreciate it.

Sincerely,

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FISH IN JUG TEST

INTRODUCTION

In this experiment one will test a body of water to see if it will sustain pond life. The results of this test will not give specific contaminants but 3will provide evidence to see if the water needs to be testered in more detail.

OBJECTIVE

To determine if the body of water is suitable for pond life.

MATERIALS

Styrofoam discs--2 ft. in diameter
empty 2 liter bottles with caps
plastic ties
soldering gun (for holes)
fishing line
weights (brick or rock)
markers
minnows

PROCEDURES

1. Use soldering gun to make small holes in the plastic 2 liter bottles. Be sure holes are small enough to keep fish in.
2. Make 2 holes around the center of the styrofoam discs.
3. Label each disc by number or letter.
4. Use plastic ties to connect the bottle to the styrofoam disc.
5. Attach fishing line to bottle on opposite side of styrofoam disc.
6. Make fishing line long enough to anchor the weight (brick or rock) down so the bottle will be stationary on the surface of the water.
7. Fill bottom of bottle with water, then put six minnows in each bottle.
8. Submerge bottle in water so that the styrofoam disc can be seen.
9. Return to check minnows daily.
10. Record observations on data table.

DATA TABLE: SEE ATTACHED SHEET

RESULTS AND CONCLUSIONS

Why does a sudden temperature change in the water kill the fish?

Does depth of water affect experiment? Explain.

Item F

Table 1-1 4/28

	4/29	4/30	5/1	5/4
Jug 1		Set out jug with fish	All fish were alive	Jug missing Possibly overturned
Jug 2	Set out jug with fish	Jug missing Appears overturned		
Jug 3	Set out jug with fish	Storm destroys float		
Jug 4	Set out jug with fish	All fish were alive	All fish were alive	Jug was missing Boat overturned
Jug 5	Set out jug with fish	One fish dead on bottom added more	All fish were alive.	

Item G

BIOLOGICAL CONTAMINATION

Biological contamination is caused by human wastes, anti-freeze, and bacteria that may have originated from the water and oil coming from cars and gas stations. The water samples taken from Lake were tested as the Treatment Plant for two different kinds of biological contamination. One of the tests done was for E.Coliform. E. Coliform is a type of bacteria that may cause typhoid or polio. The second test done was the indicator test called fecal coliform. Fecal coliform helps to determine if there is any harmful organisms in the water.

The results of the tests were promising, but there is a sign of possible future hazards. The E. Coliform test showed negative for polio and typhoid. The second test, fecal coliform, showed a high level of bacteria, but it is because of the large amount of animals living in the lake. The test does show that there might be a future problem.

Physcal Pollution

On the sunny day of May 6, 1992, our Chemistry class visited Lake with the will to clean up some of the odorous garbage surrounding what was once a beautiful lake for the public to admire. We found many different kinds of pollution in many forms, the most obvious was physical pollution. Many examples of physical pollution that we found were: bread wrappers, grocery sacks, styrofoam, beer bottles and soda cans. All of these examples can not be absorbed by the earth. High School students were concerned enough to clean as much as possible in the one hour class time we had. We managed to gather up six bags of trash in this period of time. This is only a small dent in the problem concerning Lake's pollution. In order to complete our task, we needed the communities help, also.

CHEMICAL CONTAMINATION

A Chemical contaminant is any unnatural substance that adversely effects the purity of water. The chemical contaminants are usually unseen like cyanide and nitrogen and can be harmful to living things.

When plants and animals die, organic and inorganic chemicals that make them up pollute the water. Another big problem is runoff from land as a result of rain, flood, and leaf fall. Fertilizers, oils, antifreeze, and pesticides contribute to contamination. People and their wastes are also a serious problem.

After thorough testing of samples of water from Lake with the Water Pollution Detection Outfit, we have determined that the water is safe for fish and other wildlife to live in. We have found that the water has a safe pH level. Of the substances that the water was tested for, no harmful amounts of any were found.

CONCLUSION

We, Mr fourth period chemistry class, studied water contamination and determined that Lake (located in the neighborhood) was neither biologically nor chemically polluted, but it was and still is physically contaminated.

What enabled us to determine that Lake was not chemically or biologically contaminated were the various chemical tests we did in class and the tests done at the Treatment Plant. There were no harmful amounts of chemicals present nor biological wastes.

However, Lake was and still is physically contaminated. To help solve this problem, we as a class went to Lake and collected all the trash we could. We wrote the Parks and Recreation Department and suggested that they post "Do Not Litter" signs and place more trash cans around the lake.

The last thing we did was write an origianl pamphlet informing the neighborhood on how to keep from polluting the lake. We spent two days passing out 450 pamphlets to the surrounding houses.

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Work Sample & Commentary: *Who? Me? Pollute?* continued

1 Reading	2 Writing	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communications Tools & Techniques	3 Information Tech Tools & Techniques	4 Learning & Self-mgmt Tools & Techniques	5 Tools & Techniques for Working With Others

Applied Learning

Item H

Dear Mr

Over the past four weeks, our chemistry class has been working on a project to study water contamination. Our goal was to determine if Lake (located in Candleridge neighborhood) is physically, biologically and/or chemically contaminated, to devise a plan to clean it up or keep it clean, and to educate the surrounding residence of how they can prevent further contamination.

During our study of Lake, we noticed a large amount of physical contamination. To our surprise there were only a few trash cans for public use. Also, there were no "DO NOT LITTER SIGNS" anywhere in the surrounding area. On May 8, our class picked up 11 bags of trash. There is still more trash in the lake that we could not reach.

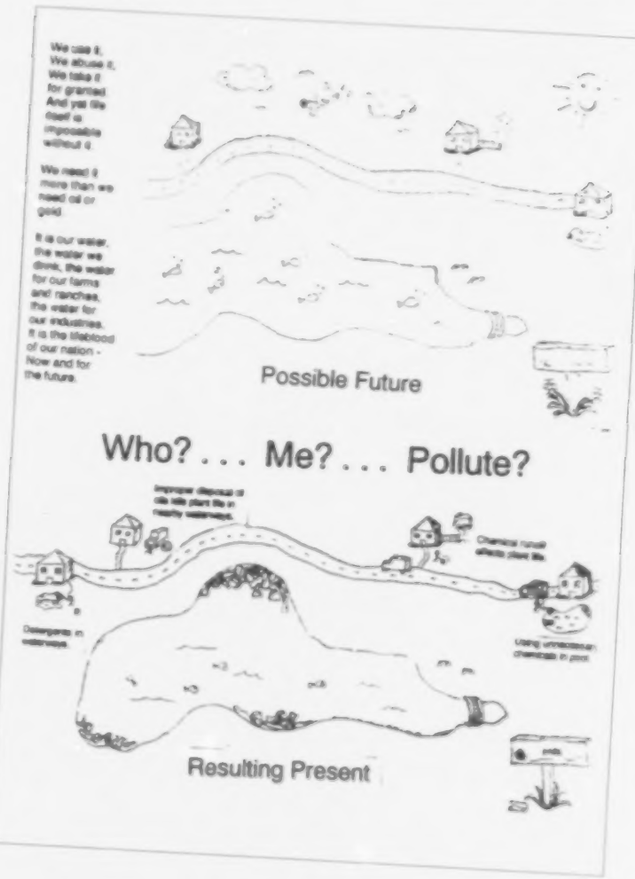
In class we also tested the water for chemical contaminants by using a water testing kit. We tested two samples and found all chemical levels to be safe and a good pH level. We also sent the lake water over to the Fort Worth Water Dept., and they detected fecal coliform at a safe level.

Based on our research, we would like to make the following recommendations:
1. Readily available trash cans evenly distributed around the lake.
2. "DO NOT LITTER" signs posted around the lake.
3. A professional physical cleaning of apparent physical contamination.

Please seriously consider these recommendations and respond to our class no later than May 19, 1992. Your time and efforts are greatly appreciated.

Sincerely,

Item I


We use it.
We abuse it.
We take it for granted.
And yet life itself is impossible without it.
We need it more than we need oil or gold.
It is our water, the water we drink, the water for our farms and ranches, the water for our industries. It is the lifeblood of our nation - Now and for the future.
Possible Future
Who? . . . Me? . . . Pollute?
Detergents in water supply
Chemical runoff affects plant life
Using unnecessary chemicals in yard
Resulting Present

We, the students of High School, have been studying the chemical, physical and biological impurities in French Lake for the past six weeks. In our Chemistry class, while working with the cooperation and support of area businesses and environmental agencies, we devised a plan to educate the community. This pamphlet is a result of our careful testing and observations.

WHAT YOU CAN DO:

1. **Do Not Litter.** The main form of pollution that we found was physical because of the presence of garbage.

2. **Properly dispose of motor oil and anti-freeze.** Improperly disposed motor oils and anti-freeze run off into nearby bodies of water.

3. **Avoid careless use of lawn chemicals.** Overuse of fertilizers and other herbicides and pesticides can cause runoff into area water supplies.

4. **Prevent detergents from entering waterways.** Avoid using soaps that may harm the environment while washing your car.

Conserving our water and improving its quality should be important to all of us. Find out more about what you can do--we owe it to future generations. For more information on improving the water quality in your neighborhood call 1-800-THE-SOIL.

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Work Sample & Commentary: *Drug Free Schools and Communities*

1 Reading	2 Writing	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

1 Number & Operation Concepts	2 Geometry & Measurement Concepts	3 Function & Algebra Concepts	4 Statistics & Probability Concepts	5 Problem Solving & Mathematical Reasoning	6 Mathematical Skills & Tools	7 Mathematical Communication	8 Putting Mathematics to Work

Mathematics

1 Physical Sciences Concepts	2 Life Sciences Concepts	3 Earth & Space Sciences Concepts	4 Scientific Connections & Applications	5 Scientific Thinking	6 Scientific Tools & Technologies	7 Scientific Communication	8 Scientific Investigation

Science

1 Problem Solving	2 Communication Tools & Techniques	3 Information Tech. Tools & Techniques	4 Learning & Self-mgmt Tools & Techniques	5 Tools & Techniques for Working With Others

Applied Learning

The work presented from this project is not a comprehensive record of all work done as part of the project. This is partly because the project was not done with a view to providing evidence of these standards and partly because it would be neither reasonable nor appropriate to ask students to keep detailed written records of every aspect of every project. This would defeat part of the purpose of Applied Learning which is for students to learn from projects that have strong links to the world of work. Some of these standards better lend themselves to assessment through observation and other less formal methods than through written work.

Accordingly, the range and depth of evidence on which to base commentary related to the standards varies throughout this work sample.

Applied Learning required by the task

Students in a business communications class were asked to revise a guide to resources in the community.

Circumstances of performance

Following an exhibition of their class work at an educational fair, students in a business communications class were commissioned to redesign the school district's resource guide, Drug Free Schools and Communities. The project began with a booklet designed for adult use. The task became more complex because the client expanded the audience from adults to both students and adults. The teacher assisted the class in an advisory role only.

This project gave students the opportunity to provide evidence related to the following Applied Learning standards:

Standard 1, Problem Solving—designing:

Standard 2, Communication Tools and Techniques—prepares a formal written proposal or report;

Standard 3, Information Technology Tools and Techniques;

Standard 5, Tools and Techniques for Working With Others—participates in self-directed work teams; completes a project in response to a commission from a client.

Problem Solving—Designing

The student designs a product, service, or system to meet an identified need; that is, the student:

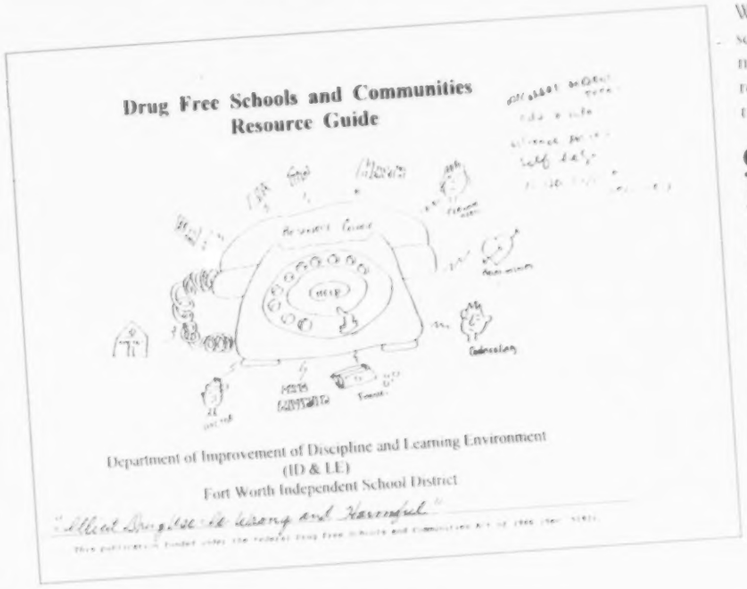
- **develops a design proposal that:**
  - **shows how the ideas have been developed;**
  - **reflects awareness of similar work done by others and of relevant design standards and regulations;**
  - **justifies the choices made, for example, with reference to functional, aesthetic, social, economic, and environmental considerations;**
  - **describes, where relevant, the principles on which decisions were based, such as, aesthetic, mathematical, and scientific;**
  - **establishes criteria for evaluating the product, service, or system;**
  - **uses appropriate conventions to represent designs;**
  - **communicates clearly so that a peer or colleague could use it;**
- **organizes, implements, and adjusts the production process to:**
  - **achieve specified standards of quality and safety;**
  - **make efficient use of time and resources;**
  - **evaluates the product, service, or system in terms of the criteria established in the design proposal, using:**
- **information gathered from impact studies or product testing or market research, as appropriate;**
- **comparisons with similar work done by others.**

The project documentation suggests that the students:

- **evaluated the existing resource guide to develop a new design; see the annotations on the sample pages from the old version of the guide (Items A and B);**
- **made design choices resulting in significant changes to the design of the resource guide, including reducing the size of the guide to make it more convenient for carrying, changing the cover to make the guide more visually appealing, changing the format of the inside pages to make the key information easier to find (compare Items A and B with the remaining items);**
- **checked and updated information: some organizations are deleted in the new guide or are shown with changed information, while others have been added (compare Item B with Item D);**
- **experimented with formats to respond to readers' needs by using devices such as bold headers and italics to visually delineate the organizations and services offered (Item C) before arriving at the final format (Item D);**
- **developed several designs for the cover (Items E, F, and G) and combined the design concepts contained in those designs to produce the final cover (Item H).**

While the evidence does not provide for a detailed commentary in relation to all of the points set out under the description of the standard, such as establishing criteria for evaluating the product, it is clear that the students undertook a designing task for a real purpose and audience and attended to many of the considerations highlighted in the standard.

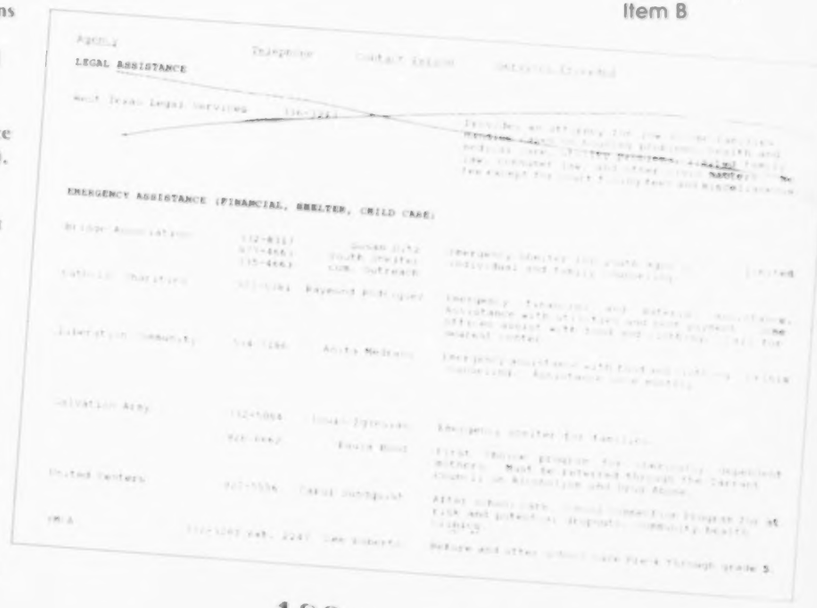
Item A


Drug Free Schools and Communities
Resource Guide

Department of Improvement of Discipline and Learning Environment
(ID & LE)
Fort Worth Independent School District

"Illicit Drug Use is Wrong and Harmful"

Item B


LEGAL ASSISTANCE

EMERGENCY ASSISTANCE (FINANCIAL, SHELTER, CHILD CARE)

What makes this task appropriate for the high school level is the range of information students needed to manage in producing the revised resource guide and the importance that attaches to getting information of this sort right.

Communication Tools and Techniques

The student prepares a formal written proposal or report to a community organization or business; that is, the student:

- **organizes the information in the proposal or report in a logical way appropriate to its purpose;**
- **produces the proposal or report in a format similar to that used for professionally produced documents for a similar purpose and audience.**

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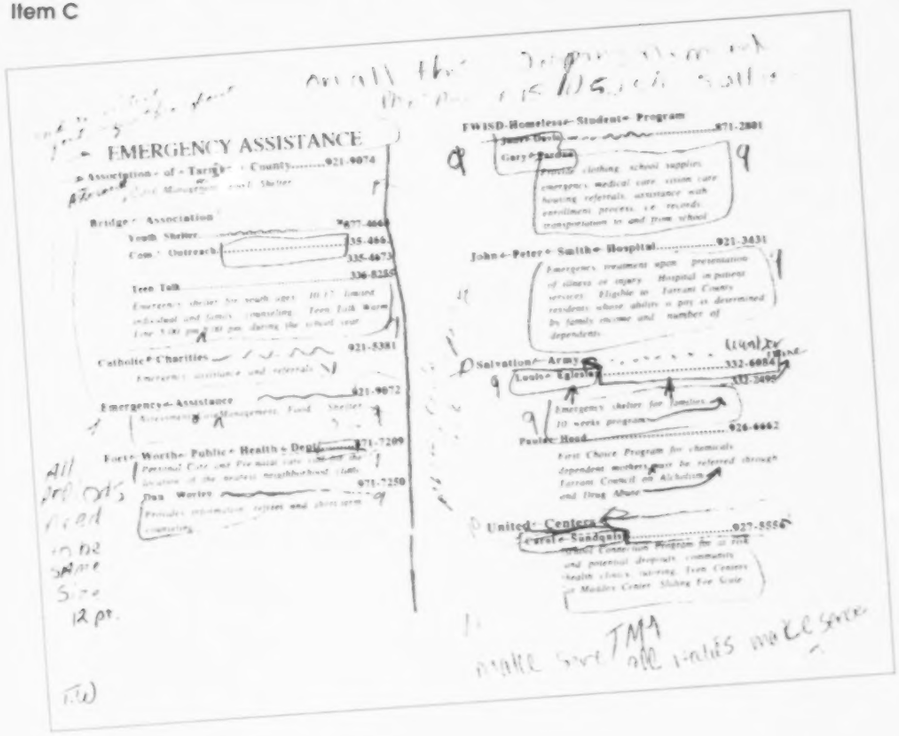
Item C



In this project, the product might be regarded as constituting a formal written report. The evidence shows attention to organizing the information in a logical way appropriate to its purpose and producing the report in a format similar to that used for professionally produced documents for a similar purpose and audience.

The material illustrates the use of word processing to collect, update, and organize data; the use of software features to manipulate the information in order to make the pages more textually appealing and accessible to the reader; experimentation with different formats and layouts and graphics; and the use of desktop publishing to produce the final draft of the resource guide in camera ready format. These aspects of the project demonstrate application of this standard at the middle school level. There is no evidence to show the extent to which students managed the computer equipment and peripherals themselves or tackled problems that may have arisen in operating the equipment and software.

Information Technology Tools and Techniques

The student:

- **sets up and operates computer equipment and associated peripherals;**
- **troubleshoots problems in operating computer equipment and software;**
- **uses on-line sources to exchange information for specific purposes.**

Tools and Techniques for Working With Others

The student participates in the establishment and operation of self-directed work teams; that is, the student:

- **identifies the range of knowledge and skills required for a given project;**
- **defines roles and shares responsibilities among team members;**
- **sets objectives and time frames for the work to be completed;**
- **establishes processes for group decision making;**
- **reviews progress and makes adjustments as required.**

The students tackled this project as a team. The variety of handwriting styles shown in the notes on **Item C** suggests that they established an accountability system of initialing their comments and suggestions, consistent with shared responsibility. However, the evidence does not provide for detailed commentary in relation to this part of the standard for Tools and Techniques for Working With Others.

The student completes a task in response to a commission from a client; that is, the student:

- **negotiates with the client to arrive at a plan for meeting the client's needs that is acceptable to the client, achievable within available resources, and includes agreed-upon criteria for successful completion;**
- **monitors client satisfaction with the work in progress and makes adjustments accordingly;**
- **evaluates the result in terms of the negotiated plan and the client's evaluation of the result.**

This task arose from a direct commission, that is, the client approached the class directly, whereas in many cases the concept and identification of a client emerges in the course of the project rather than from the outset. The client established an adult committee to act as a reference group for the students during the course of the project. The adult committee gave feedback when students presented drafts to them, and the liaison committee member provided information as requested by the class. The project spanned a year before the client was satisfied with the final product. The resource guide is currently distributed throughout the school district and community.

It is clear that the students undertook steps consistent with those set out in the description of this standard in order to complete the project. From the information available, it would also appear that completing a project in response to this commission presented a considerable challenge at the high school level. It is no mean feat for high school students to maintain purpose and momentum in a project that takes a year to complete to the client's satisfaction. Unfortunately, the available evidence does not allow for detailed commentary on the processes the students adopted to manage the client relationship in this project.

Item D

HEALTH AND HUMAN SERVICES
Emergency Assistance Association of Tarrant County 921-9074
Fuel Management, Food, Shelter
Bridge Association
Emergency Youth Shelter
Community Outreach 877-4663
Teen Talk 335-4673
Emergency shelter for youth ages 10-17 (limited individual and family counseling, Teen Talk Warm Line 5:00 p.m.-8:00 p.m. during the school year) 336-8255
Catholic Charities 921-5381
Emergency assistance and referrals
Fort Worth Public Health Dept. 871-7209
Personal care and pre-natal care clinic for the residents of the neutral neighborhood clinic
FWISD Homeless Student Program
June Davis, director
Gary Pardue (department) 871-2801 871-2801
Provides clothing, school supplies, emergency medical care, vision care, housing referrals, assistance with enrollment process, i.e. records, transportation to and from school
John Peter Smith Hospital 921-3431
Emergency treatment upon presentation of illness or injury. Hospital in-patient services. Eligible to Tarrant County residents whose ability to pay is determined by family income and number of dependents.
Salvation Army
Louis Eglesia (family services) 332-6084
(clothing services) 332-2495
Emergency shelter for families
10 weeks program
Paula Hood 926-6662
First Choice Program for chemically dependent mothers must be referred through Tarrant County Council on Alcoholism and Drug Abuse
Social Security Administration 1-800-772-1213
Services provided: Supplemental Security Income (SSI) Assistance program based on financial need (not past work) for the aged, blind, disabled. Medicare benefits. Children of retired or deceased workers are eligible also.
Spanish speaking staff available
Teen Work Study Program
11
12

In England, the curriculum for Design & Technology describes students working at the secondary school level in the following way: "When designing and making, pupils systematically seek out information to aid their design thinking, recognizing the needs of a variety of client groups. Their design proposals show originality. They arrive at a justifiable optimum solution through drawing and modeling, and communicate to others the key features of their designs, together with details that will aid manufacture."

Design & Technology in the National Curriculum, p. 28.

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Work Sample & Commentary: *Drug Free Schools and Communities* continued

1 Reading	2 Writing	3 Speaking, Listening & Viewing	4 Conventions, Grammar & Usage	5 Literature	6 Public Documents	7 Functional Documents

English Language Arts

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Mathematics

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Science

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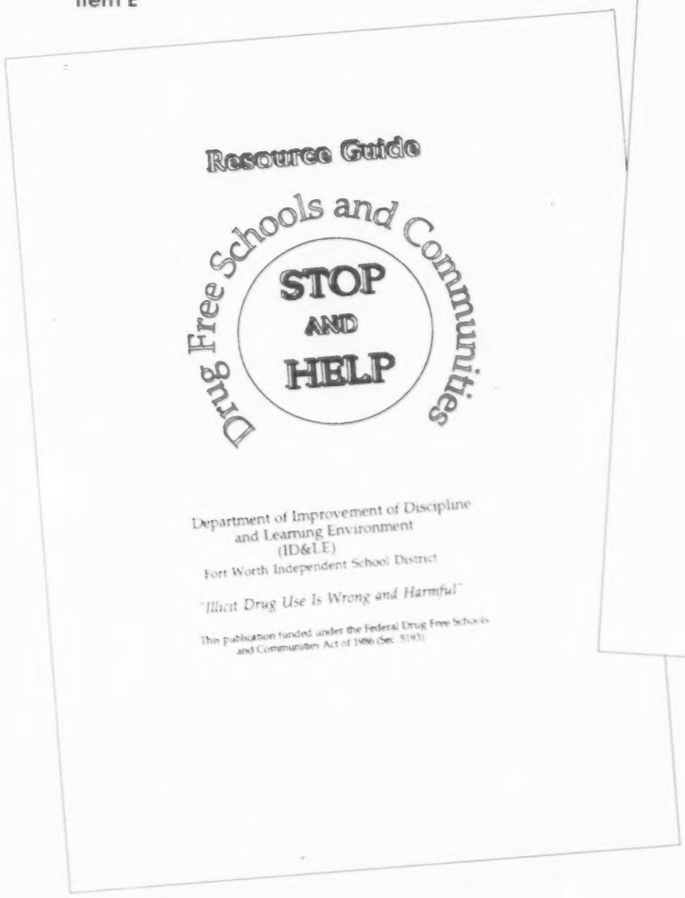
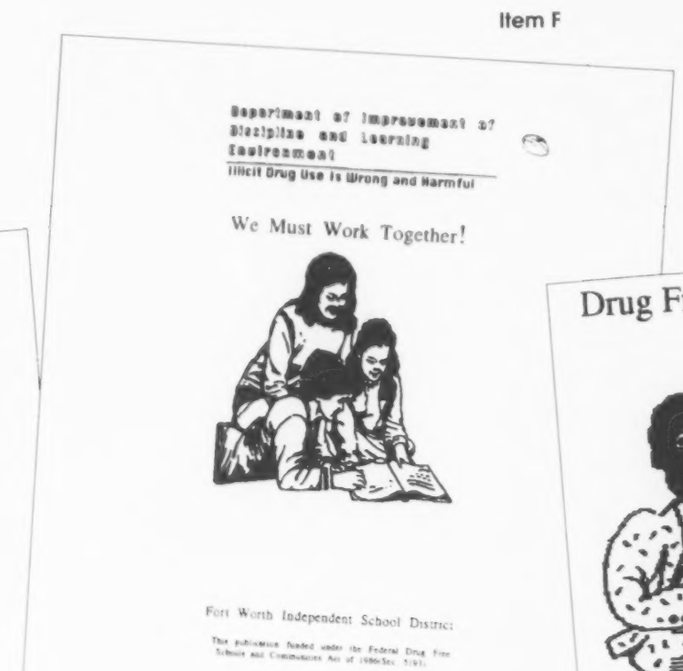
Applied Learning

Item E


Resource Guide
Drug Free Schools and Communities
STOP
AND
HELP
Department of Improvement of Discipline and Learning Environment (ID&LE)
Fort Worth Independent School District
"Illicit Drug Use Is Wrong and Harmful"
This publication funded under the Federal Drug Free Schools and Communities Act of 1986 (Sec. 5193)

Item F


Department of Improvement of Discipline and Learning Environment
Illicit Drug Use Is Wrong and Harmful
We Must Work Together!
Fort Worth Independent School District
This publication funded under the Federal Drug Free Schools and Communities Act of 1986(Sec. 5193)

Item G

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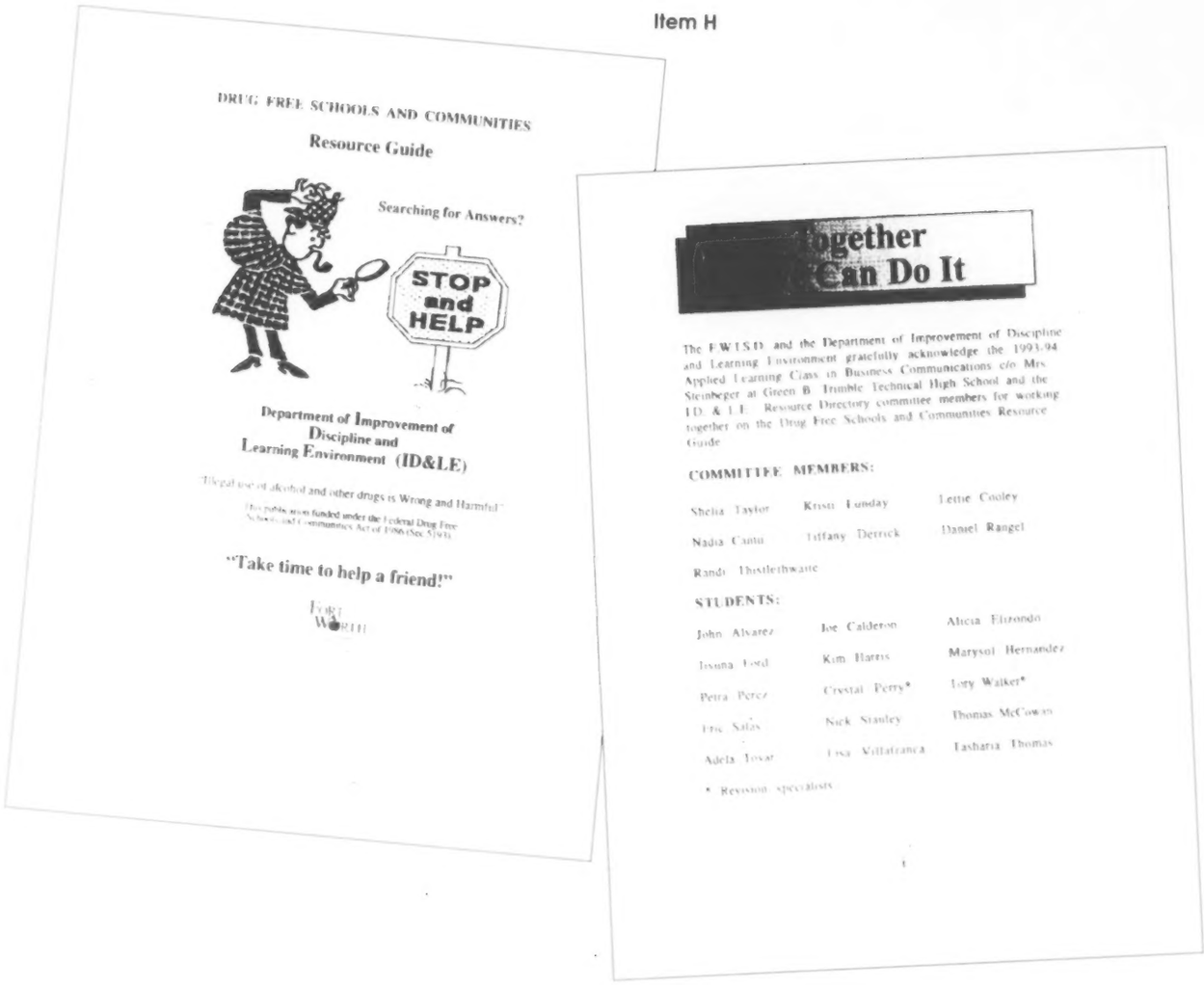
Item H



DRUG FREE SCHOOLS AND COMMUNITIES

Resource Guide

Searching for Answers?

STOP and HELP

Department of Improvement of Discipline and Learning Environment (ID&LE)

"Illegal use of alcohol and other drugs is Wrong and Harmful"

This publication funded under the Federal Drug Free Schools and Communities Act of 1986 (Sec. 5141).

"Take time to help a friend!"

FORT WORTH

ogether
an Do It

The F.W.I.S.D. and the Department of Improvement of Discipline and Learning Environment gratefully acknowledge the 1993-94 Applied Learning Class in Business Communications c/o Mrs. Steinbeger at Green B. Trimble Technical High School and the I.D. & L.E. Resource Directory committee members for working together on the Drug Free Schools and Communities Resource Guide.

COMMITTEE MEMBERS:

Shelia Taylor, Kristi Lunday, Lettie Cooley, Nadia Cantu, Tiffany Derrick, Daniel Rangel, Randi Thistlethwaite

STUDENTS:

John Alvarez, Joe Calderon, Alicia Elizondo, Iesuna Ford, Kim Harris, Marysol Hernandez, Petra Perez, Crystal Perry*, Lory Walker*, Eric Salas, Nick Stanley, Thomas McCowan, Adela Tovar, Lisa Villafranca, Lasharia Thomas

* Revision specialists

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APPENDIX 1

The elementary school standards are set at a level of performance approximately equivalent to the end of fourth grade. The middle school standards are set at a level of performance approximately equivalent to the end of eighth grade. The high school standards are set at a level of performance approximately equivalent to the end of tenth grade. It is expected that some students might achieve these levels earlier and others later than these grades.

An array of work is required to achieve any single standard. The work becomes increasing refined and sophisticated as students get older. The complexity of the tasks used to generate the work also increases. This notion of requiring students to hone the sophistication of their performances while simultaneously working with increasingly complex assignments cuts across all the English Language Arts standards.

The number of books required to meet this standard does not increase as students get older, but the length and complexity of what is read does increase, so, this standard becomes increasingly formidable.

The reading requirement assumes an adequate library of appropriate reading material. In some places, library resources are too meager to support the amount of reading required for every student to achieve this standard. Where a shortage of books exists, better use of out-of-school resources must be made; for example, students may have to be assured access to local or county libraries.

Reading twenty-five books a year entails a substantial amount of time. Students may use materials read in conjunction with their regular class work, including courses other than English, to satisfy this requirement.

ELEMENTARY SCHOOL

The student reads and comprehends material of the quality and complexity illustrated in the sample reading list equivalent to twenty-five books each year. The materials should include traditional and contemporary children's literature or the equivalent in children's magazines, newspapers, textbooks, and media, from at least three different literary forms and from at least five different writers. The student produces evidence of reading that:

- demonstrates a thorough understanding of the text as a whole;
- identifies complexities presented in the text, i.e., ideas, information, levels of meaning;
- extracts salient information from the text;
- uses paraphrasing judiciously.

The student reads in depth at least four books (or book equivalents) about one issue or subject, or four books by a single writer, or four books in one genre, and produces evidence of reading that:

- makes and supports warranted and responsible assertions about the texts;
- supports assertions with elaborated and convincing evidence;
- makes perceptive and well developed connections;
- evaluates writing strategies and elements of the author's craft.

The student reads informational materials to develop understanding and expertise and produces written or oral work that:

- restates or summarizes information;
- relates new information to prior knowledge and experience;
- extends ideas;
- makes connections to related topics or information.

The student reads aloud, accurately (in the range of 85-90%), familiar material of the quality and complexity illustrated in the sample reading list, and in a way that makes meaning clear to listeners by:

- self correcting when subsequent reading indicates an earlier miscue;
- using a range of cueing systems, e.g., phonics and context clues, to determine pronunciation and meanings;
- reading with a rhythm, flow, and meter that sounds like everyday speech.

MIDDLE SCHOOL

The student reads and comprehends material of the quality and complexity illustrated in the sample reading list equivalent to twenty-five books each year. The materials should include traditional and contemporary literature or the equivalent in magazines, newspapers, textbooks, and media, from at least three different literary genres and from at least five different writers. The student produces evidence of reading that:

- demonstrates a thorough understanding of the text as a whole;
- identifies complexities presented in the text, i.e., ideas, information, levels of meaning;
- extracts salient information from the text;
- uses paraphrasing judiciously.

The student reads in depth at least four books (or book equivalents) about one issue or subject, or four books by a single writer, or four books in one genre, and produces evidence of reading that:

- makes and supports warranted and responsible assertions about the texts;
- supports assertions with elaborated and convincing evidence;
- makes perceptive and well developed connections;
- evaluates writing strategies and elements of the author's craft.

The student reads informational materials to develop understanding and expertise and produces written or oral work that:

- restates or summarizes information;
- relates new information to prior knowledge and experience;
- extends ideas;
- makes connections to related topics or information.

The student demonstrates familiarity with a variety of public documents and produces written or oral work that:

- identifies the author's purpose and stance;
- analyzes the arguments and positions advanced and the evidence offered in support of them;
- identifies common persuasive techniques.

The student demonstrates familiarity with a variety of functional documents and produces written or oral work that:

- identifies the sequence of activities needed to carry out a procedure;
- analyzes the formatting techniques used to make a document user-friendly;
- identifies any information that is either extraneous or missing.

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HIGH SCHOOL

The student reads and comprehends material of the quality and complexity illustrated in the sample reading list equivalent to twenty-five books each year. The materials should include traditional and contemporary literature or the equivalent in magazines, newspapers, textbooks, and media, from at least three different literary genres and from at least five different writers. The student produces evidence of reading that:

- demonstrates a thorough understanding of the text as a whole;
- identifies complexities presented in the text, i.e., ideas, information, levels of meaning;
- extracts salient information from the text;
- uses paraphrasing judiciously.

The student reads in depth at least four books (or book equivalents) about one issue or subject, or four books by a single writer, or four books in one genre, and produces evidence of reading that:

- makes and supports warranted and responsible assertions about the texts;
- supports assertions with elaborated and convincing evidence;
- makes perceptive and well developed connections;
- evaluates writing strategies and elements of the author's craft.

The student reads informational materials to develop understanding and expertise and produces written or oral work that:

- restates or summarizes information;
- relates new information to prior knowledge and experience;
- extends ideas;
- makes connections to related topics or information.

6. Public Documents

The student produces at least one public document, in which the writer:

- exhibits an awareness of the importance of precise word choice and the power of imagery and/or anecdote;
- utilizes and recognizes the power of logical arguments, arguments based on appealing to a reader's emotions, and arguments dependent upon the writer's persona;
- uses arguments that are appropriate in terms of the knowledge, values, and degree of understanding of the intended audience;
- uses a range of strategies to appeal to readers.

The student critiques at least one public document, with an eye to strategies common in public discourse, including:

- effective use of argument;
- use of the power of anecdote;
- anticipation of counter claims;
- appeal to audiences both friendly and hostile to the position presented;
- use of emotionally laden words and imagery;
- citing of appropriate references or authorities.

7. Functional Documents

The student produces at least one functional document, appropriate to audience and purpose, in which the writer:

- reports, organizes, and conveys information and ideas accurately;
- includes relevant narrative details, such as scenarios, definitions, examples;
- anticipates readers' problems, mistakes, and misunderstandings;
- uses a variety of formatting techniques, including headings, subordination, or even foregrounding of main ideas, hierarchical structures, graphics, and color;
- establishes a persona that is consistent with the document's purpose;
- employs word choices that are consistent with the persona and appropriate for the intended audience.

The student critiques at least one functional document, with an eye to strategies common to good functional documents, including:

- visual appeal, e.g., format, graphics, white space, headers;
- logic of the sequence in which the directions are given;
- awareness of possible reader misunderstandings.

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ELEMENTARY SCHOOL

Fiction:
Brink, *Caddie Woodlawn;*
Cleary, *Ramona and Her Father;*
Coert, *The Josefina Story Quilt;*
Cohen, *Fat Jack;*
De Saint-Exupery, *The Little Prince;*
Hamilton, *Zeely;*
Hansen, *The Gift-Giver;*
Lord, *In the Year of the Boar and Jackie Robinson;*
Mendez and Byard, *The Black Snowman;*
Naidoo, *Journey to JoBurg;*
O'Dell, *Zia;*
Ringgold, *Tar Beach;*
Speare, *The Sign of the Beaver;*
Yep, *Child of the Owl.*

Non-Fiction:
Aliki, *Corn Is Maize: The Gift of the Indians;*
Baylor, *The Way to Start a Day;*
Cherry, *The Great Kapok Tree;*
Epstein, *History of Women in Science for Young People;*
Greenfield, *Childtimes: A Three-Generation Memoir;*
Godkin, *Wolf Island;*
Hamilton, *Anthony Burns: The Defeat and Triumph of a Fugitive Slave;*
McKissack, *Frederick Douglass: The Black Lion;*
Politi, *Song of the Swallows;*
Sattler, *Dinosaurs of North America;*
Fritz, *And Then What Happened, Paul Revere?;*
McGovern, *The Secret Soldier: The Story of Deborah Sampson.*

Poetry:
Ahlberg, *Heard It in the Playground;*
Blishen and Wildsmith, *Oxford Book of Poetry for Children;*
De Regniers, Moore, White, and Carr, eds., *Sing a Song of Popcorn;*
Giovanni, *Ego-Tripping and Other Poems for Young People;*
Greenfield, *Honey, I Love and Other Love Poems;*
Heard, *For the Good of the Earth and Sun;*
Janeczko, *Strings: A Gathering of Family Poems;*
Koch and Farrell, eds., *Talking to the Sun;*
Lobel, ed., *The Random House Book of Mother Goose;*
Manguel, ed., *Seasons;*
Mathis, *Red Dog, Blue Fly: Football Poems;*
Silverstein, *Where the Sidewalk Ends.*

Folklore:
Griego y Maestas, *Cuentos: Tales From the Hispanic Southwest;*
French, *Snow White in New York;*
Huck and Lobel, *Princess Furball;*
Louie and Young, *Yeh-Shen: A Cinderella Story From China;*
Luenn, *The Dragon Kite;*
Goble, *Buffalo Woman;*
Steptoe, *Mufaro's Beautiful Daughters;*
Steptoe, *The Story of Jumping Mouse;*
Kipling, *The Elephant's Child;*
Lee, *Legend of the Milky Way.*

Modern Fantasy and Science Fiction:
Andersen, *The Ugly Duckling;*
Bond, *A Bear Called Paddington;*
Dahl, *James and the Giant Peach;*
Grahame, *The Wind in the Willows;*
Lewis, *The Lion, The Witch and The Wardrobe;*
Norton, *The Borrowers;*
Van Allsburg, *Jumanji;*
White, *Charlotte's Web.*

Children's magazines:
Weekly Reader;
Creative Classroom;
Social Studies for the Young Learner;
World (National Geographic);
News (Scholastic);
Action (Scholastic);
Local newspapers or their equivalents.

Other: Manuals appropriate for elementary school children, e.g., Nintendo, other computer manuals.

MIDDLE SCHOOL

Fiction:
Anaya, *Bless Me, Ultima;*
Armstrong, *Sounder;*
Bonham, *Durango Street;*
Cohen, *Tell Us Your Secret;*
Collier, *My Brother Sam Is Dead;*
Cormier, *I Am the Cheese;*
Danziger, *The Cat Ate My Gymsuit;*
Fast, *April Morning;*
Gaines, *A Gathering of Old Men;*
Goldman, *The Princess Bride;*
Greene, *Summer of My German Soldier;*
Hansen, *Which Way Freedom;*
Hinton, *The Outsiders;*
Holman, *Slake's Limbo;*
London, *The Call of the Wild;*
Mathis, *Listen for the Fig Tree;*
Mohr, *Nilda;*
Neufeld, *Lisa, Bright and Dark;*
O'Brien, *Z for Zachariah;*
Reiss, *The Upstairs Room;*
Schaefer, *Shane;*
Stevenson, *Treasure Island;*
Voigt, *Dicey's Song;*
Walker, *To Hell With Dying;*
Walter, *Because We Are;*
Zindel, *The Pigman.*

Non-Fiction:
Amory, *The Cat Who Came for Christmas;*
Berck, *No Place to Be: Voices of Homeless Children;*
Frank, *The Diary of a Young Girl;*
George, *The Talking Earth;*
Gilbreth, *Cheaper by the Dozen;*
Haskins, *Outward Dreams;*
Hautzig, *Endless Steppe: A Girl in Exile;*
Herriott, *All Creatures Great and Small;*
Lester, *To Be a Slave;*
Meyers, *Pearson, a Harbor Seal Pup;*
Soto, *Living Up the Street;*
White, *Ryan White: My Own Story;*
Yates, *Amos Fortune, Free Man.*

Poetry:
Adams, *Poetry of Earth and Sky;*
Eliot, *Old Possum's Book of Practical Cats;*
Frost, *You Come Too;*
Greenfield, *Night on Neighborhood Street;*
Livingston, *Cat Poems.*

Drama:
Blinn, *Brian's Song;*
Davis, *Escape to Freedom;*
Gibson, *The Miracle Worker;*
Lawrence and Lee, *Inherit the Wind;*
Osborn, *On Borrowed Time;*
Shakespeare, *A Midsummer Night's Dream;*
Stone, *Metamora, or, the Last of the Wampanoags.*

Folklore/Mythology:
Blair, *Tall Tale America;*
Bruchac, *The First Strawberries: A Cherokee Story;*
Bryan, *Beat the Story-Drum, Pum-Pum;*
D'Aulaire, *Norse Gods and Giants;*
Gallico, *The Snow Goose;*
Lee, *Toad Is the Uncle of Heaven: A Vietnamese Folk Tale;*
Pyle, *Merry Adventures of Robin Hood.*

Modern Fantasy and Science Fiction:
Bradbury, *Dandelion Wine;*
Babbitt, *Tuck Everlasting;*
Cooper, *The Grey King;*
Hamilton, *The Magical Adventures of Pretty Pearl;*
L'Engle, *A Wrinkle in Time;*
Tolkien, *The Hobbit;*
Yep, *Dragon of the Lost Sea.*

Magazines/Periodicals:
Scope (Scholastic);
World (National Geographic);
Junior Scholastic (Scholastic);
Science World (Scholastic);
Cobblestone (American history);
Calliope (world history);
Faces (anthropology);
Odyssey (science).

Other: Computer manuals; instructions; contracts. See also the reading lists included in award books corresponding to reading provided by the Girl Scouts of America and the Boy Scouts of America.

HIGH SCHOOL

Fiction:
Brito, *The Devil in Texas;*
Carroll, *Alice in Wonderland;*
Cisneros, *The House on Mango Street;*
Clark, *The Ox-Bow Incident;*
Golding, *Lord of the Flies;*
Hawthorne, *The Scarlet Letter;*
Hemingway, *For Whom the Bell Tolls;*
Hentoff, *The Day They Came to Arrest the Book;*
Hilton, *Goodbye, Mr. Chips;*
Kinsella, *Shoeless Joe;*
Knowles, *A Separate Peace;*
Lee, *To Kill a Mockingbird;*
McCullers, *The Heart Is a Lonely Hunter;*
Orwell, *1984;*
Paulsen, *Canyons;*
Portis, *True Grit;*
Potok, *Davita's Harp;*
Steinbeck, *Travels With Charley in Search of America;*
Wartski, *A Boat to Nowhere;*
Welty, *The Golden Apples.*

Non-Fiction:
Angell, *Late Innings;*
Angelou, *I Know Why the Caged Bird Sings;*
Ashe, *Days of Grace;*
Beal, *"I Will Fight No More Forever": Chief Joseph and the Nez Perce War;*
Bishop, *The Day Lincoln Was Shot;*
Bloom, *The Closing of the American Mind;*
Campbell, *The Power of Myth;*
Covey, *Seven Habits of Highly Effective People;*
Galarza, *Barrio Boy;*
Hawking, *A Brief History of Time;*
Houston, *Farewell to Manzanar;*
Kennedy, *Profiles in Courage;*
Kingsley and Levitz, *Count Us In: Growing Up With Down Syndrome;*
Kingston, *Woman Warrior;*
Mazer, ed., *Going Where I'm Coming From;*
Momaday, *The Way to Rainy Mountain;*
Rodriquez, *Hunger of Memory;*
Sternberg, *User's Guide to the Internet;*
Wright, *Black Boy.*

Poetry:
Angelou, *I Shall Not be Moved;*
Bly, ed., *News of the Universe;*
Cummings, *Collected Poems;*
Dickinson, *Complete Poems;*
Randall, ed., *The Black Poets;*
Carruth, ed., *The Voice That Is Great Within Us;*
Hughes, *Selected Poems;*
Knudson and Swenson, eds., *American Sports Poems;*
Longfellow, *Evangeline;*
Wilbur, *Things of This World.*

Drama:
Christie, *And Then There Were None;*
Hansberry, *A Raisin in the Sun;*
McCullers, *The Member of the Wedding;*
Pomerance, *The Elephant Man;*
Rose, *Twelve Angry Men;*
Rostand, *Cyrano de Bergerac;*
Shakespeare, *Romeo and Juliet; Julius Caesar;*
Van Druten, *I Remember Mama;*
Wilder, *The Skin of Our Teeth;*
Wilson, *The Piano Lesson.*

Folklore/Mythology:
Evslin, *Adventures of Ulysses;*
Pinsent, *Greek Mythology;*
Stewart, *The Crystal Cave;*
Burland, *North American Indian Mythology;*
White, *The Once and Future King.*

Modern Fantasy and Science Fiction:
Adams, *Watership Down;*
Asimov, *Foundation;*
Bradbury, *The Martian Chronicles;*
Clarke, *2001: A Space Odyssey;*
Clarke, *Childhood's End;*
Frank, *Alas, Babylon;*
Herbert, *Dune;*
Lewis, *Out of the Silent Planet;*
McCaffrey, *Dragonflight;*
Twain, *A Connecticut Yankee in King Arthur's Court;*
Verne, *20,000 Leagues Under the Sea.*

Magazines and Newspapers:
Omni;
Sports Illustrated;
Literary Cavalcade (Scholastic);
National Geographic;
Smithsonian;
Newsweek;
Time.

Other: Computer manuals; instructions; contracts; technical materials.

APPENDIX 1

These standards allow for oral performances of student work whenever appropriate.

Much writing can be classified as belonging to the public arena. New Standards, however, defines public documents to mean only those pieces of text that are concerned with public policy, that address controversial issues confronting the public, or that arise in response to controversial issues or public policy. Public documents are included in the Reading standard at middle school and constitute a separate standard at high school. At the middle school level, the issues students write about come primarily from the school or local community. At high school, students should address issues which are of national importance.

Functional writing is writing that exists in order to get things done. Functional writing is ordinarily considered technical writing and, as such, is often not part of the typical English curriculum. New Standards requires students to demonstrate proficiency with functional writing because such writing is of increasing importance to the complex literacy of our culture. Functional documents are included in the Reading standard at middle school and constitute a separate standard, Standard 7, at high school.

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2. Writing

APPENDIX 1

The "response to literature" in the Writing standard is meant to replace the more typical literary analysis paper that many students routinely produce in conjunction with literature study. This does not preclude literary analysis but instead opens up possibilities for reader response as well.

It is not intended that all student work developed to meet the English Language Arts standards should necessarily come from an English class. The challenge is to ensure that Mathematics, Science, and Applied Learning work samples are incorporated widely into the English Language Arts work samples, thus encouraging students to use work from other classes while not weakening the English curriculum.

ELEMENTARY SCHOOL

The student produces four types of writing.

A report, in which the writer:

- engages the reader by establishing a context, creating a persona, and otherwise developing reader interest;
- develops a controlling idea that conveys a perspective on the subject;
- creates an organizing structure appropriate to a specific purpose, audience, and context;
- includes appropriate facts and details;
- excludes extraneous and inappropriate information;
- uses a range of appropriate strategies, such as providing facts and details, describing or analyzing the subject, and narrating a relevant anecdote.

A response to literature, in which the writer:

- engages the reader by establishing a context, creating a persona, and otherwise developing reader interest;
- advances a judgment that is interpretive, analytic, evaluative, or reflective;
- supports a judgment through references to the text, references to other works, authors, or non-print media, or references to personal knowledge;
- demonstrates understanding of the literary work.

A narrative account (fictional or autobiographical), in which the writer:

- engages the reader by establishing a context, creating a point of view, and otherwise developing reader interest;
- establishes a situation, plot, point of view, setting, and conflict (and for autobiography, the significance of events);
- creates an organizing structure;
- includes sensory details and concrete language to develop plot and character;
- excludes extraneous details and inconsistencies;
- develops complex characters;
- uses a range of appropriate strategies, such as dialogue and tension or suspense.

A narrative procedure, in which the writer:

- engages the reader by establishing a context, creating a persona, and otherwise developing reader interest;
- provides a guide to action that anticipates a reader's needs, creates expectations through predictable structures, e.g., headings, and provides transitions between steps;
- makes use of appropriate writing strategies, such as creating a visual hierarchy and using white space and graphics as appropriate;
- includes relevant information;
- excludes extraneous information;
- anticipates problems, mistakes, and misunderstandings that might arise for the reader.

MIDDLE SCHOOL

The student produces five types of writing.

A report, in which the writer:

- engages the reader by establishing a context, creating a persona, and otherwise developing reader interest;
- develops a controlling idea that conveys a perspective on the subject;
- creates an organizing structure appropriate to purpose, audience, and context;
- includes appropriate facts and details;
- excludes extraneous and inappropriate information;
- uses a range of appropriate strategies, such as providing facts and details, describing or analyzing the subject, narrating a relevant anecdote, comparing and contrasting, naming, and explaining benefits or limitations.

A response to literature, in which the writer:

- engages the reader through establishing a context, creating a persona, and otherwise developing reader interest;
- advances a judgment that is interpretive, analytic, evaluative, or reflective;
- supports a judgment through references to the text, references to other works, authors, or non-print media, or references to personal knowledge;
- demonstrates an understanding of the literary work;
- anticipates and answers a reader's questions.

A narrative account (fictional or autobiographical), in which the writer:

- engages the reader by establishing a context, creating a point of view, and otherwise developing reader interest;
- establishes a situation, plot, point of view, setting, and conflict (and for autobiography, the significance of events and of conclusions that can be drawn from those events);
- creates an organizing structure;
- includes sensory details and concrete language to develop plot and character;
- excludes extraneous details and inconsistencies;
- develops complex characters;
- uses a range of appropriate strategies, such as dialogue, tension or suspense, naming, and specific narrative action, e.g., movement, gestures, expressions.

A narrative procedure, in which the writer:

- engages the reader by establishing a context, creating a persona, and otherwise developing reader interest;
- provides a guide to action for a relatively complicated procedure in order to anticipate a reader's needs, creates expectations through predictable structures, e.g., headings, and provides smooth transitions between steps;
- makes use of appropriate writing strategies, such as creating a visual hierarchy and using white space and graphics as appropriate;
- includes relevant information;
- excludes extraneous information;
- anticipates problems, mistakes, and misunderstandings that might arise for the reader.

A persuasive essay, in which the writer:

- engages the reader by establishing a context, creating a persona, and otherwise developing reader interest;
- develops a controlling idea that makes a clear and knowledgeable judgment;
- creates an organizing structure that is appropriate to the needs, values, and interests of a specified audience, and arranges details, reasons, examples, and anecdotes effectively and persuasively;
- includes appropriate information and arguments and excludes information and arguments that are irrelevant;
- anticipates and addresses reader concerns and counter arguments;
- supports arguments with detailed evidence, citing sources of information as appropriate.

HIGH SCHOOL

The student produces six types of writing.

A report, in which the writer:

- engages the reader by establishing a context, creating a persona, and otherwise developing reader interest;
- develops a controlling idea that conveys a perspective on the subject;
- creates an organizing structure appropriate to purpose, audience, and context;
- includes appropriate facts and details;
- excludes extraneous and inappropriate information;
- uses a range of appropriate strategies, such as providing facts and details, describing or analyzing the subject, narrating a relevant anecdote, comparing and contrasting, naming, explaining benefits or limitations, demonstrating claims or assertions, and providing a scenario to illustrate.

A response to literature, in which the writer:

- engages the reader through establishing a context, creating a persona, and otherwise developing reader interest;
- advances a judgment that is interpretive, analytic, evaluative, or reflective;
- supports a judgment through references to the text, references to other works, authors, or non-print media, or references to personal knowledge;
- demonstrates understanding of the literary work through suggesting an interpretation;
- anticipates and answers a reader's questions;
- recognizes possible ambiguities, nuances, and complexities.

A narrative account (fictional or autobiographical), in which the writer:

- engages the reader by establishing a context, creating a point of view, and otherwise developing reader interest;
- establishes a situation, plot, point of view, setting, and conflict (and for autobiography, the significance of events and of conclusions that can be drawn from those events);
- creates an organizing structure;
- includes sensory details and concrete language to develop plot and character;
- excludes extraneous details and inconsistencies;
- develops complex characters;
- uses a range of appropriate strategies, such as dialogue, tension or suspense, naming, pacing, and specific narrative action, e.g., movement, gestures, expressions.

A narrative procedure, in which the writer:

- engages the reader by establishing a context, creating a persona, and otherwise developing reader interest;
- provides a guide to action for a complicated procedure in order to anticipate a reader's needs; creates expectations through predictable structures, e.g., headings; and provides smooth transitions between steps;
- makes use of appropriate writing strategies, such as creating a visual hierarchy and using white space and graphics as appropriate;
- includes relevant information;
- excludes extraneous information;
- anticipates problems, mistakes, and misunderstandings that might arise for the reader.

A persuasive essay, in which the writer:

- engages the reader by establishing a context, creating a persona, and otherwise developing reader interest;
- develops a controlling idea that makes a clear and knowledgeable judgment;
- creates an organizing structure that is appropriate to the needs, values, and interests of a specified audience, and arranges details, reasons, examples, and anecdotes effectively and persuasively;
- includes appropriate information and arguments and excludes information and arguments that are irrelevant;
- anticipates and addresses reader concerns and counter arguments;
- supports arguments with detailed evidence, citing sources of information as appropriate;
- uses a range of strategies to elaborate and persuade, such as definitions, descriptions, illustrations, examples from evidence, and anecdotes.

A reflective essay, in which the writer:

- engages the reader by establishing a context, creating a persona, and otherwise developing reader interest;
- analyzes a condition or situation of significance;
- develops a commonplace, concrete occasion as the basis for the reflection, e.g., personal observation or experience;
- creates an organizing structure appropriate to purpose and audience;
- uses a variety of writing strategies, such as concrete details, comparing and contrasting, naming, describing, creating a scenario.

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3. Speaking, Listening, and Viewing

ELEMENTARY SCHOOL

The student accesses and exchanges information; that is, the student:

- asks appropriate questions;
- responds to the questions of others;
- paraphrases and summarizes to increase understanding;
- listens responsively to others' points of view;
- uses language which is simple and appropriate for communicating;
- speaks audibly;
- makes appropriate eye contact;
- respects turn taking of other speakers;
- uses language and gestures expressively and persuasively;
- shows awareness of an audience by adjusting to its reaction.

The student responds to oral presentations; that is, the student:

- asks appropriate questions;
- paraphrases and summarizes to increase understanding;
- speaks audibly;
- uses language and gestures expressively and persuasively;

The student makes informed judgments about television, radio, and film productions; that is, the student:

- articulates reasoned judgments for selecting particular television and radio productions and rejecting others;
- recounts the story elements of television, radio, and film productions;
- identifies the intended messages of advertisements, entertainment programs, and news programs.

MIDDLE SCHOOL

The student accesses and exchanges information; that is, the student:

- asks appropriate questions;
- responds to the questions of others;
- paraphrases and summarizes to increase understanding;
- listens responsively to others' points of view;
- uses language which is simple and appropriate for communicating;
- speaks audibly;
- makes appropriate eye contact;
- respects turn taking of other speakers;
- uses language and gestures expressively and persuasively;
- shows awareness of an audience by adjusting to its reaction.

The student responds to oral presentations; that is, the student:

- asks appropriate questions;
- paraphrases and summarizes to increase understanding;
- speaks audibly;
- uses language and gestures expressively and persuasively.

The student makes informed judgments about television, radio, and film productions; that is, the student:

- articulates reasoned judgments for selecting particular television and radio productions and rejecting others;
- recounts the story elements of television, radio, and film productions;
- identifies the intended messages of advertisements, entertainment programs, and news programs;
- identifies common persuasive techniques used in advertising;
- describes ways used to portray and comment on the general culture.

HIGH SCHOOL

The student accesses and exchanges information; that is, the student:

- asks appropriate questions;
- responds to the questions of others;
- paraphrases and summarizes to increase understanding;
- listens responsively to others' points of view;
- uses language which is simple and appropriate for communicating;
- speaks audibly;
- makes appropriate eye contact;
- respects turn taking of other speakers;
- uses language and gestures expressively and persuasively;
- shows awareness of an audience by adjusting to its reaction.

The student responds to oral presentations; that is, the student:

- asks appropriate questions;
- paraphrases and summarizes to increase understanding;
- speaks audibly;
- uses language and gestures expressively and persuasively.

The student makes informed judgments about television, radio, and film productions; that is, the student:

- articulates reasoned judgments for selecting particular television and radio programs and rejecting others;
- recounts the story elements of television, radio, and film productions;
- identifies the intended messages of advertisements, entertainment programs, and news programs;
- identifies the common persuasive techniques used in advertising;
- describes ways used to portray and comment on the general culture;
- demonstrates an understanding of media stereotyping and other socially significant portrayals;
- understands the effects of media production techniques on viewers' perceptions, including the use of music, camera angles, fade-outs.

APPENDIX 1

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4. Conventions, Grammar, and Usage of the English Language

APPENDIX 1

ELEMENTARY SCHOOL

The student regularly uses, with some teacher assistance, appropriate conventions of the English language, including:

- spelling;
- sentence construction;
- paragraph structure;
- punctuation;
- grammar;
- usage.

The student analyzes and revises written work, as appropriate, relative to audiences and purposes by:

- adding or deleting details;
- adding or deleting explanations;
- clarifying difficult passages;
- rearranging words, sentences, and paragraphs to improve or clarify meaning;
- sharpening the focus;
- reconsidering the organizational structure.

MIDDLE SCHOOL

The student independently uses appropriate conventions of the English language, including:

- spelling;
- sentence construction;
- paragraph structure;
- punctuation;
- grammar;
- usage.

The student analyzes and revises written work, as appropriate, relative to audiences and purposes by:

- adding or deleting details;
- adding or deleting explanations;
- clarifying difficult passages;
- rearranging words, sentences, and paragraphs to improve or clarify meaning;
- sharpening the focus;
- reconsidering the organizational structure.

HIGH SCHOOL

The student independently and habitually uses the appropriate conventions of the English language, including:

- spelling;
- sentence construction;
- paragraph structure;
- punctuation;
- grammar;
- usage.

The student analyzes and revises written work, as appropriate, relative to audiences and purposes by:

- adding or deleting details;
- adding or deleting explanations;
- clarifying difficult passages;
- rearranging words, sentences, and paragraphs to improve or clarify meaning;
- sharpening the focus;
- reconsidering the organizational structure.

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5. Literature

ELEMENTARY SCHOOL

The student responds to fiction, non-fiction, poetry, and drama using interpretive, critical, and evaluative processes; that is, the student does one or more of the following in oral and written presentations:

- examines the reasons for a character's actions, taking into account the situation and basic motivation of the character;
- identifies recurring themes across works;
- identifies stereotypical characters as opposed to fully developed characters;
- critiques the degree to which a plot is contrived or realistic;
- makes inferences and draws conclusions about context, events, characters, and setting;
- analyzes the impact of authors' decisions regarding word choice and content;
- considers the function of point of view or persona;
- considers the differences among genres;
- evaluates literary merit.

The student writes works in specific genres that incorporate appropriate literary features.

MIDDLE SCHOOL

The student responds to fiction, non-fiction, poetry, and drama using interpretive, critical, and evaluative processes; that is, the student does one or more of the following in oral and written presentations:

- analyzes the reasons for a character's actions, taking into account the situation and basic motivation of the character;
- identifies recurring themes across works;
- identifies stereotypical characters as opposed to fully developed characters;
- makes inferences and draws conclusions about context, events, characters, setting, and theme;
- identifies the effect of literary devices such as figurative language, allusion, diction, dialogue, and description;
- interprets the impact of authors' decisions regarding word choice, content, and literary elements;
- identifies the characteristics of literary forms and genres;
- evaluates literary merit;
- identifies the effect of point of view.

The student demonstrates proficiency in at least one literary genre.

HIGH SCHOOL

The student responds to fiction, non-fiction, poetry, and drama using interpretive, critical, and evaluative processes; that is, the student does one or more of the following in oral and written presentations:

- makes inferences and draws conclusions about content, events, characters, setting, theme, and style;
- interprets the effect of literary devices, such as figurative language, allusion, diction, dialogue, description, symbolism;
- evaluates the impact of authors' decisions regarding word choice, style, content, and literary elements;
- analyzes the characteristics of literary forms and genres;
- evaluates literary merit;
- explains the effect of point of view;
- makes thematic connections among literary texts, public discourse, and media;
- interprets ambiguities, subtleties, contradictions, ironies, and nuances;
- demonstrates how literary works reflect the period which shaped them.

The student demonstrates proficiency in at least one literary genre.

APPENDIX 1

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APPENDIX 2

The elementary school standards are set at a level of performance approximately equivalent to the end of fourth grade. The middle school standards are set at a level of performance approximately equivalent to the end of eighth grade. The high school standards are set at a level of performance approximately equivalent to the end of tenth grade. It is expected that some students might achieve these levels earlier and others later than these grades.

ELEMENTARY SCHOOL

The student:

- adds, subtracts, multiplies, and divides whole numbers, with and without calculators; that is, the student:
  - adds, i.e., joins things together, increases;
  - subtracts, i.e., takes away, compares, finds the difference;
  - multiplies, i.e., uses repeated addition, counts by multiples, combines things that come in groups, makes arrays, uses area models, computes simple scales, uses simple rates;
  - divides, i.e., puts things into groups, shares equally; calculates simple rates;
  - analyzes problem situations and contexts in order to figure out when to add, subtract, multiply, or divide;
  - solves arithmetic problems by relating addition, subtraction, multiplication and division to one another;
  - computes answers mentally, e.g., 27 + 45, 30 x 4;
  - uses simple concepts of negative numbers, e.g., on a number line, in counting, in temperature, "owing";
- demonstrates understanding of the base ten place value system and uses this knowledge to solve arithmetic tasks; that is, the student:
  - counts 1, 10, 100 or 1,000 more than or less than, e.g., one less than 100,000, 10 more than 380, 1,000 more than 23,000, 100 less than 9,000, during arithmetic activities and problem solving;
- uses knowledge about ones, tens, hundreds and thousands to figure out answers to multiplication and division tasks, e.g. 36 x 10, 18 x 100, 7 x 1,000, 4,000 ÷ 4, during arithmetic activities and problem solving;
- estimates, approximates, rounds off, or uses exact numbers, as appropriate, in calculations;
- describes and compares quantities by using simple fractions; that is, the student:
  - finds simple parts of wholes;
  - recognizes simple fractions as instructions to divide, e.g., $\frac{1}{4}$ of something is the same as dividing something by 4;
  - recognizes the place of fractions on number lines, e.g., in measurement;
  - uses drawings, diagrams, or models to show what the numerator and denominator mean, including when adding like fractions, e.g., $\frac{1}{8} + \frac{5}{8}$;
  - uses beginning proportional reasoning and simple ratios, e.g., "about half of the people";
- describes and compares quantities by using decimals; that is, the student:
  - adds, subtracts, multiplies, and divides money amounts;
  - recognizes that decimals are another way of writing fractions, e.g., 0.3 = $\frac{3}{10}$;
  - recognizes relationships among simple fractions, decimals, and percents, e.g., that $\frac{1}{2}$ is the same as 0.5, and $\frac{1}{2}$ is the same as 50%;
- describes and compares quantities by using whole numbers up to 1,000,000; that is, the student:
  - connects ideas of quantities to the real world, e.g., how many people fit in a baseball stadium; how far away is a kilometer in your city;
  - finds, identifies, and sorts numbers by their properties, e.g., odd, even; and for two-digit numbers, prime, square, and composite.

MIDDLE SCHOOL

The student:

- consistently and accurately adds, subtracts, multiplies, and divides rational numbers; raises rational numbers to whole number powers;
- understands the inverse relationships between addition and subtraction, multiplication and division, and exponentiation and root-extraction; and uses the inverse operation to determine unknown quantities in equations;
- consistently and accurately computes with, applies, and converts the different kinds and forms of rational numbers, i.e., integers (both whole numbers and negative integers) and other positive and negative rationals, written as decimals, as percents, or as proper, improper, or mixed fractions; irrational numbers, i.e., those that cannot be written as a ratio of two integers, are not required but are suitable for introduction, especially since the student should be familiar with the irrational number π;
- is familiar with characteristics of operations and numbers, e.g., divisibility, prime factorization, and with properties of rational numbers, e.g., commutativity and associativity, short of formal statements;
- interprets percent as part of 100 and as a means of comparing quantities of different sizes or changing sizes;
- reasons proportionally to solve problems involving equivalent fractions or equal ratios;
- orders numbers with the > and < relationships and by location on a number line and has a sense of the magnitudes and relative magnitudes of numbers; note that scientific notation is not required.

HIGH SCHOOL

The student:

- uses the properties of addition, subtraction, multiplication, division, exponentiation, and root-extraction in forming and working with algebraic expressions;
- understands and uses unary operations, such as opposite, reciprocal, absolute value, raising to a fixed power, taking a root, and taking a logarithm;
- has facility with the mechanics of binary and unary operations as well as understanding of their typical meaning and uses in applications;
- understands and uses number systems, that is, natural, integer, rational, and real;
- represents numbers in decimal or fraction form and in scientific notation, and graphs numbers on the number line and in the coordinate plane;
- compares numbers of different magnitude using order relations, differences, ratios, proportions, percents, proportional change, and location on the number line;
- uses dimensionless numbers, such as proportions, percents, and multiplicative factors, and numbers with specific units of measure, including length, time, and rate units;
- recognizes and represents basic number patterns.

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2. Geometry and Measurement Concepts

APPENDIX 2

ELEMENTARY SCHOOL

The student:

- works with many types of figures and their properties, including angles (right, obtuse, acute), triangles, squares, rectangles, rhombi, parallelograms, quadrilaterals, polygons, prisms, pyramids, cubes, circles, and spheres;
- identifies, classifies, and names geometric figures by specific shape properties, e.g., symmetry;
- solves problems by showing relationships between and among figures, e.g., using congruence and similarity, and using transformations including flips, slides, and rotations;
- extends and creates geometric patterns using concrete and pictorial models;
- uses basic ways of measuring the size of figures, including length, width, perimeter, and area;
- uses models to reason about the relationship between the perimeter and area of rectangles in simple situations;
- selects and uses appropriate units for measuring quantities such as weight, length, area, volume, and time;
- carries out simple unit conversions, such as between cm and m, and between hours and minutes;
- measures and creates a scale in maps or scale drawings using the idea of constant ratio.

MIDDLE SCHOOL

The student:

- is familiar with assorted two- and three-dimensional objects, including squares, triangles, other polygons, circles, cubes, rectangular prisms, i.e., "boxes," pyramids, spheres, and cylinders;
- identifies similar and congruent shapes and uses transformations in the coordinate plane, i.e., translations, rotations, and reflections;
- understands length, area, and volume (as well as the differences between these measurements) and the corresponding uses of units, square units, and cubic units of measure;
- recognizes similarity and rotational and bilateral symmetry in two- and three-dimensional figures;
- analyzes and generalizes geometric patterns, such as tessellations and sequences of shapes;
- measures angles, weights, capacities, times, and temperatures using appropriate units;
- chooses appropriate units of measure and converts with ease between like units, e.g., inches and miles, within a customary or metric system; note that conversions between customary and metric are not required;
- reasons proportionally in situations with similar figures;
- reasons proportionally with measurements to interpret maps and to make smaller and larger scale drawings;
- models situations geometrically to formulate and solve problems.

HIGH SCHOOL

The student:

- works with many types of figures and their properties, including polygons and circles, cubes and pyramids, and cylinders, cones, and spheres;
- uses relationships between figures involving congruence and similarity; and characterizes such properties in terms of transformations;
- knows, uses, and derives formulas for area, surface area, and volume of many types of figures;
- uses the Pythagorean Theorem in many types of situations and knows how to prove the theorem;
- works with similar triangles and extends the ideas to include definitions and simple uses of the three basic trigonometric functions;
- analyzes figures in terms of the kinds of symmetries they have;
- studies geometric patterns, including sequences of growing shapes and characterizes the pattern in terms of properties of the n^{th} stage;
- works with geometric measures of length, area, surface area, volume, and angle; and non-geometric measures of weight, monetary value, and time;
- uses quotient measures, such as speed and density, relating them to slope and "per unit" amounts; and uses product measures such as person-days;
- understands the structure of standard measurement systems, both SI and customary, including derived units, unit conversions, and dimensional analysis;
- carries out proportional reasoning: in cases involving expansions and contractions, that is, in situations where sizes in the expanded or contracted figure are proportional to the corresponding sizes in the original figure; and in cases involving figures composed of many identical parts, that is, in situations where the size of the whole is proportional to the number of parts;
- solves problems involving scale and change of scale in maps and diagrams;
- represents geometric curves and graphs of functions in standard coordinate systems;
- analyzes geometric figures and proves things about them using deductive methods;
- models situations geometrically to formulate and solve problems.

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APPENDIX 2

ELEMENTARY SCHOOL

The student:

- uses linear patterns to solve problems; that is, the student:
  - shows how one quantity determines another in a linear pattern, i.e. describes, extends, and recognizes the linear pattern by its rule, such as, the total number of legs on a given number of horses can be calculated by counting by fours;
  - shows how one quantity determines another quantity in a functional relationship based on a linear pattern, e.g., for the "number of people and total number of eyes," figure out how many eyes 100 people have all together;
- builds iterations of simple non-linear patterns, including multiplicative and squaring patterns, with concrete materials and recognizes that these patterns are not linear;
- shows that an equality relationship between two quantities remains the same as long as the same change is made to both quantities;
- uses letters, boxes, or other symbols to stand for any number, measured quantity, or object in simple situations with concrete materials, i.e., demonstrates understanding and use of a beginning concept of a variable.

MIDDLE SCHOOL

The student:

- discovers, describes, and generalizes patterns, including linear, exponential, and simple quadratic relationships, i.e., those of the form $f(n)=n^2$ or $f(n)=cn^2$, for constant c, including $A=\pi r^2$, and represents them with variables and expressions;
- represents relationships with tables, graphs in the coordinate plane, and verbal or symbolic rules;
- analyzes tables, graphs, and rules to determine functional relationships;
- finds solutions for unknown quantities in linear equations and in simple equations and inequalities.

HIGH SCHOOL

The student:

- models given situations with linear, exponential, or quadratic functions and interprets given functions in terms of situations;
- discovers, describes, generalizes, and uses basic types of functions; that is, linear, exponential, periodic, power, rational, squares and square roots, and cubes and cube roots;
- works with properties and mechanics of functions; that is, evaluation, inverses, slope, local maxima and minima;
- works with many kinds of rate relationships in constant rate situations;
- uses linear (arithmetic) sequences and exponential (geometric) sequences;
- defines and uses variables, parameters, constants, and unknowns in work with both functions and equations;
- solves equations both symbolically and graphically, especially linear, quadratic, and exponential equations; and knows the quadratic formula and its derivation;
- represents functional relationships in formulas, tables, and graphs, and translates among these;
- understands the basic algebraic structure of number systems;
- is familiar with 2 by 2 matrices, their arithmetic, and some of their uses, such as solving systems of equations and representing symmetries and transformations;
- uses equations to represent curves such as lines, circles, ellipses, parabolas, and hyperbolas;
- uses functions to represent patterns.

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4. Statistics and Probability Concepts

ELEMENTARY SCHOOL

The student:

- collects and organizes data to answer a question or test a hypothesis by comparing sets of data;
- displays data in graphs, tables, and charts;
- makes statements and draws simple conclusions based on data; that is, the student:
  - reads for information data in tables, charts, and graphs;
  - compares data in order to make true statements, e.g., "seven plants grew at least 5 cm";
  - identifies and uses the mode necessary for making true statements, e.g., "most people chose red";
  - makes true statements based on a simple concept of "average" or mean, for a small sample size and where the situation is made evident with concrete materials or clear representations;
  - interprets data to determine the reasonableness of statements about the data, e.g., "twice as often," "three times faster";
  - uses data, including statements about the data, to make a simple concluding statement about a situation, e.g., "This kind of plant grows better near sunlight because the seven plants that were near the window grew at least 5 cm";
- gathers data about an entire group or by sampling group members to understand the concept of "sample", e.g., that a large sample leads to more reliable information;
- predicts and finds out why some outcomes are more likely, less likely, or equally likely;
- finds all possible combinations and arrangements within certain constraints involving a limited number of variables.

MIDDLE SCHOOL

The student:

- collects and organizes data and displays data with appropriate tables, charts, and graphs;
- analyzes data with respect to characteristics of frequency and distribution, including mode and range;
- analyzes appropriately central tendencies of data with mean and median;
- makes conclusions and recommendations based on data analysis;
- critiques the conclusions and recommendations of others' statistics;
- considers effects on reliability of sampling procedures and of missing or incorrect information;
- formulates hypotheses to answer a question and uses data to test hypotheses;
- recognizes equally likely outcomes, constructs sample spaces, and determines probabilities of events;
- makes predictions based on experimental or theoretical probabilities;
- predicts the result of a series of trials once the probability for one trial is known.

HIGH SCHOOL

The student:

- collects, organizes, displays, and analyzes single-variable data using frequency distributions, histograms, and summary statistics;
- collects, organizes, displays, and analyzes two-variable data using scatter plots, estimated regression lines, and computer-generated regression lines and correlation coefficients;
- understands the role of assumptions and uncertainty in making inferences;
- critiques conclusions and the use of statistics in public documents;
- uses sampling techniques to draw inferences about large populations;
- explores questions of experimental design, use of control groups, and reliability;
- formulates hypotheses to answer a question and uses data to test hypotheses;
- uses theoretical probability models to arrive at probabilities for chance events;
- uses experimental measures of likelihood based on gathering of data to arrive at relative frequencies for chance events;
- uses simulations to estimate probabilities;
- sets up and works with appropriate sample spaces and applies the addition and multiplication principles appropriately;
- works with the normal distribution in some of its basic uses.

APPENDIX 2

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5. Problem Solving and Mathematical Reasoning

APPENDIX 2

ELEMENTARY SCHOOL

The student solves problems that make significant demands in one or more of these aspects of the solution process: problem formulation, problem implementation, and problem conclusion.

Problem formulation
The student participates in the formulation of problems; that is, given the basic statement of a problem situation, the student:

- makes decisions about the approach, materials, and strategies to use;
- uses previously learned strategies, skills, knowledge, and concepts to make decisions;
- uses strategies, such as using manipulatives or drawing sketches, to model problems;
- does not merely fill in a given chart, use a pre-specified manipulative or go through a predetermined set of steps.

Problem implementation
The student makes the basic choices involved in planning and carrying out a solution; that is, the student:

- makes up and uses a variety of strategies and approaches to solving problems and learns approaches that other people use;
- makes connections among concepts in order to solve problems;
- solves problems in ways that make sense and explains why these ways make sense, e.g., defends the reasoning, explains the solution.

Problem conclusion
The student moves beyond a particular problem by making connections, extensions, and/or generalizations; for example, the student:

- explains a pattern that can be used in similar situations;
- explains how the problem is similar to other problems he or she has solved;
- explains how the mathematics used in the problem is like other concepts in mathematics;
- explains how the problem solution can be applied to other school subjects and in real world situations;
- makes the solution into a general rule that applies to other circumstances.

MIDDLE SCHOOL

The student solves problems that make significant demands in one or more of these aspects of the solution process: problem formulation, problem implementation, and problem conclusion.

Problem formulation
The student:

- formulates and solves a variety of meaningful problems;
- extracts pertinent information from situations and figures out what additional information is needed;
- formulates conjectures and argues, short of formal proof, why they must be or seem true.

Problem implementation
The student:

- uses and invents a variety of approaches and understands and evaluates those of others;
- invokes problem solving strategies, such as illustrating with sense making sketches to clarify situations or organizing information in a table;
- determines, where helpful, how to break a problem into simpler parts;
- solves for unknown or undecided quantities using algebra, graphing, sound reasoning, and other strategies;
- integrates concepts and techniques from different areas of mathematics;
- works effectively in teams when the nature of the task or the allotted time makes this an appropriate strategy;
- makes sensible, reasonable estimates;
- makes justified, logical statements.

Problem conclusion
The student:

- verifies and interprets results with respect to the original problem situation;
- generalizes solutions and strategies to new problem situations.

HIGH SCHOOL

The student solves problems that make significant demands in one or more of these aspects of the solution process: problem formulation, problem implementation, and problem conclusion.

Problem formulation
The student participates in the formulation of problems; in particular, given the basic statement of a problem situation, the student:

- fills out the formulation of a definite problem that is to be solved;
- extracts pertinent information from the situation as a basis for working on the problem;
- asks and answers a series of appropriate questions in pursuit of a solution and does so with minimal "scaffolding" in the form of detailed guiding questions.

Problem implementation
The student makes the basic choices involved in planning and carrying out a solution; in particular, the student:

- chooses and employs effective problem solving strategies in dealing with non-routine and multi-step problems;
- selects appropriate mathematical concepts and techniques from different areas of mathematics and applies them to the solution of the problem;
- applies mathematical concepts to new situations within mathematics and uses mathematics to model real world situations involving basic applications of mathematics in the physical sciences, the social sciences, and business.

Problem conclusion
The student provides closure to the solution process through summary statements and general conclusions; in particular, the student:

- concludes a solution process with a useful summary of results;
- evaluates the degree to which the results obtained represent a good response to the initial problem;
- formulates generalizations of the results obtained;
- carries out extensions of the given problem to related problems.

Mathematical Reasoning
The student not only makes observations and states results but also justifies or proves why the results hold in general; in particular, the student:

- employs forms of mathematical reasoning and proof appropriate to the solution of the problem at hand, including deductive and inductive reasoning, making and testing conjectures, and using counterexamples and indirect proof;
- differentiates clearly between giving examples that support a conjecture and giving a proof of the conjecture.

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6. Mathematical Skills and Tools

APPENDIX 2

ELEMENTARY SCHOOL

The student:

- adds, subtracts, multiplies, and divides whole numbers correctly; that is, the student:
  - knows single digit addition, subtraction, multiplication, and division facts;
  - adds and subtracts numbers with several digits;
  - multiplies and divides numbers with one or two digits;
  - multiplies and divides three digit numbers by one digit numbers;
- estimates numerically and spatially;
- measures length, area, perimeter, circumference, diameter, height, weight, and volume accurately in both the customary and metric systems;
- computes time and money; that is the student:
  - computes lengths of time in hours and minutes;
  - calculates money amounts in dollars and cents;
- refers to geometric shapes and terms correctly with concrete objects, including triangle, square, rectangle, rhombus, parallelogram, quadrilateral, polygon, polyhedron, angle (right, acute, obtuse), side, edge, face, cube, vertex, point, line, perimeter, area, volume, circle, diameter, circumference, sphere, prism, and pyramid;
- uses +, −, x, ÷, /, $\frac{}{}$, $, ¢, %, and . (decimal point) correctly in number sentences and expressions;
- reads, creates, and represents data on charts, tables, diagrams, bar graphs, simple circle graphs, and coordinate graphs;
- uses recall, mental computations, pencil and paper, measuring devices, mathematics texts, manipulatives, calculators, computers, and advice from peers, as appropriate, to achieve solutions; that is, the student:
  - uses measuring devices, graded appropriately for given situations, such as rulers (customary to the $\frac{1}{16}$ inch; metric to the millimeter), protractors, compasses, graph paper (customary to the inch or half-inch; metric to the centimeter), measuring cups (customary to the ounce; metric to the milliliter), scales (customary to the pound or ounce; metric to the kilogram or gram);
  - interprets long decimals that result from dividing on calculators, by rounding to the nearest appropriate place (whole number, tenth or hundredth).

MIDDLE SCHOOL

The student:

- computes accurately with arithmetic operations on rational numbers;
- knows and uses the correct order of operations for arithmetic computations;
- estimates numerically and spatially;
- measures length, area, volume, weight, time, and temperature accurately;
- refers to geometric shapes and terms correctly;
- uses equations, formulas, and simple algebraic notation appropriately;
- organizes data on charts and graphs, including scatter plots, bar, line, and circle graphs, and Venn diagrams;
- uses recall, mental computations, pencil and paper, measuring devices, mathematics texts, manipulatives, calculators, computers, and advice from peers, as appropriate, to achieve solutions.

HIGH SCHOOL

The student:

- computes accurately using arithmetic and algebraic operations on whole and rational numbers, using both pencil and paper and technology;
- makes reasonable estimates in appropriate units of quantities met in applications;
- evaluates and analyzes functions of many kinds, using both pencil and paper and technology;
- uses basic geometric terminology accurately and deduces information about basic geometric figures in solving problems;
- makes and uses rough sketches, schematic diagrams, or precise scale diagrams to enhance a solution;
- plots points on the number line, in the plane, and in space;
- creates and interprets graphs of many kinds, such as circle graphs, function graphs, scatter plots, regression lines, and histograms;
- sets up and solves equations symbolically (when possible) and graphically;
- uses technology to create graphs or spreadsheets that contribute to the understanding of a problem;
- knows how to write a simple computer program to carry out computations to be repeated many times;
- knows standard methods to solve basic problems and uses these methods in approaching more complex problems;
- carries out numerical calculations and symbol manipulations effectively, using mental computations, pencil and paper, or technological aids, as appropriate.

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APPENDIX 2

ELEMENTARY SCHOOL

The student:

- uses appropriate mathematical terms, vocabulary and language, based on prior conceptual work;
- shows ideas in a variety of ways, including words, numbers, symbols, pictures, charts, graphs, tables, diagrams, and models;
- explains clearly and logically solutions to problems, and supports solutions with evidence, in both oral and written form;
- considers purpose and audience when communicating;
- comprehends mathematics from reading assignments and from other sources.

MIDDLE SCHOOL

The student:

- uses mathematical language and representations with appropriate accuracy, including numerical tables and equations, simple algebraic equations and formulas, charts, graphs, and diagrams;
- organizes work, explains facets of a solution orally and in writing, labels drawings, and uses other techniques to make meaning clear to the audience;
- uses mathematical language to make complex situations easier to understand;
- exhibits developing reasoning abilities by justifying statements and defending work;
- shows understanding of concepts by explaining ideas not only to teachers and assessors but to fellow students or younger children;
- comprehends mathematics from reading assignments and from other sources.

HIGH SCHOOL

The student:

- is familiar with basic mathematical vocabulary and terminology, standard notation and use of symbols, common conventions for graphing, and general features of effective mathematical communication styles;
- uses mathematical representations with appropriate accuracy, including numerical tables, formulas, functions, algebraic equations, charts, graphs, and diagrams;
- presents mathematical procedures and results clearly, systematically, succinctly, and correctly;
- communicates logical arguments clearly, showing why a result makes sense and why the reasoning is valid;
- describes and discusses mathematical ideas effectively both orally and in writing;
- explains mathematical concepts or ideas clearly to peers or others who may be having difficulty with them;
- reads mathematical texts and other writing about mathematics with understanding.

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APPENDIX 2

ELEMENTARY SCHOOL

The student conducts at least one large scale project each year drawn from the following kinds and, over the course of elementary school, projects drawn from at least three of the kinds.

A single project may draw on more than one kind.

Data study, in which the student:

- develops a question and a hypothesis in a situation where data could help make a decision or recommendation;
- decides on a group or groups to be sampled and makes predictions of the results, with specific percents, fractions, or numbers;
- collects, represents, and displays data in order to help make the decision or recommendation; compares the results with the predictions;
- writes a report that includes recommendations supported by diagrams, charts, and graphs; acknowledges assistance received from parents, peers, and teachers.

Science study, in which the student:

- decides on a specific science question to study and identifies the mathematics that will be used, e.g., measurement;
- develops a prediction (a hypothesis) and develops procedures to test the hypothesis;
- collects and records data; represents and displays data; compares results to predictions;
- writes a report that compares the results with the hypothesis; supports the results with diagrams, charts, and graphs; acknowledges assistance received from parents, peers, and teachers.

Design of a physical structure, in which the student:

- decides on a structure to design, the size and budget constraints, and the scale of design;
- makes a first draft of the design, and revises and improves the design in response to input from peers and teachers;
- makes a final draft and report of the design, drawn and written so that another person could make the structure; acknowledges assistance received from parents, peers, and teachers.

Management and planning, in which the student:

- decides on what to manage or plan and what goal will be used to see if the plan worked;
- identifies unexpected events that could disrupt the plan and further plans for such contingencies;
- identifies resources needed, e.g., materials, money, time, space, and other people;
- writes down a detailed plan; revises and improves the plan in response to feedback from peers and teachers;
- carries out the plan (optional);
- writes up a report on the plan, that includes resources, budget, and schedule; acknowledges assistance received from parents, peers, and teachers.

Pure mathematics investigation, in which the student:

- decides on the area of mathematics to investigate, e.g., numbers, shapes, patterns;
- describes a question or concept that he or she will seek to better understand;
- decides on representations that will be used, e.g., numbers, symbols, diagrams, shapes, or physical models;
- carries out the investigation;
- writes up a report, including generalizations if there were any; acknowledges assistance received from parents, peers, and teachers.

Other kinds of projects involving putting mathematics to work, chosen by the student or teacher, in which the student:

- identifies, with the teacher, and writes down a clear purpose for the project, what will be accomplished, and how the project involves putting mathematics to work;
- develops a question and a plan; writes a detailed description of how the project was carried out, including mathematical analysis of the results; and a report that includes acknowledgment of assistance received from parents, peers, and teachers.

MIDDLE SCHOOL

The student conducts at least one large scale investigation or project each year drawn from the following kinds and, over the course of middle school, investigations or projects drawn from at least three of the kinds.

A single investigation or project may draw on more than one kind.

Data study based on civic, economic, or social issues, in which the student:

- selects an issue to investigate;
- makes a hypothesis on an expected finding;
- gathers data;
- analyzes the data using concepts from Standard 4, e.g., considering mean and median, and the frequency and distribution of the data;
- shows how the study's results compare with the hypothesis;
- uses pertinent statistics to summarize;
- prepares a presentation or report that includes the question investigated, a detailed description of how the project was carried out, and an explanation of the findings.

Mathematical model of physical phenomena, often used in science studies, in which the student:

- carries out a study of a physical system using a mathematical representation of the structure;
- uses understanding from Standard 3, particularly with respect to the determination of the function governing behavior in the model;
- generalizes about the structure with a rule, i.e., a function, that clearly applies to the phenomenon and goes beyond statistical analysis of a pattern of numbers generated by the situation;
- prepares a presentation or report that includes the question investigated, a detailed description of how the project was carried out, and an explanation of the findings.

Design of a physical structure, in which the student:

- generates a plan to build something of value, not necessarily monetary value;
- uses mathematics from Standard 2 to make the design realistic or appropriate, e.g., areas and volumes in general and of specific geometric shapes;
- summarizes the important features of the structure;
- prepares a presentation or report that includes the question investigated, a detailed description of how the project was carried out, and an explanation of the findings.

Management and planning, in which the student:

- determines the needs, e.g., cost, supply, scheduling, of the event to be managed or planned;
- notes any constraints that will affect the plan;
- determines a plan;
- uses concepts from any of Standards 1 to 4, depending on the nature of the project;
- considers the possibility of a more efficient solution;
- prepares a presentation or report that includes the question investigated, a detailed description of how the project was carried out, and an explanation of the plan.

Pure mathematics investigation, in which the student:

- extends or "plays with," as with mathematical puzzles, some mathematical feature, e.g., properties and patterns in numbers;
- uses concepts from any of Standards 1 to 4, e.g., an investigation of Pascal's triangle would have roots in Standard 1 but could tie in concepts from geometry, algebra, and probability; investigations of derivations of geometric formulas would be rooted in Standard 2 but could require algebra;
- determines and expresses generalizations from patterns;
- makes conjectures on apparent properties and argues, short of formal proof, why they seem true;
- prepares a presentation or report that includes the question investigated, a detailed description of how the project was carried out, and an explanation of the findings.

Other kinds of projects putting mathematics to work chosen by student or teacher.

HIGH SCHOOL

The student conducts at least one large scale investigation or project each year drawn from the following kinds and, over the course of high school, investigations or projects drawn from at least three of the kinds.

A single investigation or project may draw on more than one kind.

Data study, in which the student:

- carries out a study of data relevant to current civic, economic, scientific, health, or social issues;
- uses methods of statistical inference to generalize from the data;
- prepares a report that explains the purpose of the project, the organizational plan, and conclusions, and uses an appropriate balance of different ways of presenting information.

Mathematical model of a physical system or phenomenon, in which the student:

- carries out a study of a physical system or phenomenon by constructing a mathematical model based on functions to make generalizations about the structure of the system;
- uses structural analysis (a direct analysis of the structure of the system) rather than numerical or statistical analysis (an analysis of data about the system);
- prepares a report that explains the purpose of the project, the organizational plan, and conclusions, and uses an appropriate balance of different ways of presenting information.

Design of a physical structure, in which the student:

- creates a design for a physical structure;
- uses general mathematical ideas and techniques in discussing specifications for building the structure;
- prepares a report that explains the purpose of the project, the organizational plan, and conclusions, and uses an appropriate balance of different ways of presenting information.

Management and planning analysis, in which the student:

- carries out a study of a business or public policy situation involving issues such as optimization, cost-benefit projections, and risks;
- uses decision rules and strategies both to analyze options and balance trade-offs; and brings in mathematical ideas that serve to generalize the analysis across different conditions;
- prepares a report that explains the purpose of the project, the organizational plan, and conclusions, and uses an appropriate balance of different ways of presenting information.

Pure mathematics investigation, in which the student:

- carries out a mathematical investigation of a phenomenon or concept in pure mathematics;
- uses methods of mathematical reasoning and justification to make generalizations about the phenomenon;
- prepares a report that explains the purpose of the project, the organizational plan, and conclusions, and uses an appropriate balance of different ways of presenting information.

History of a mathematical idea, in which the student:

- carries out a historical study tracing the development of a mathematical concept and the people who contributed to it;
- prepares a report that explains the purpose of the project, the organizational plan, and conclusions, and uses an appropriate balance of different ways of presenting information.

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APPENDIX 3

The elementary school standards are set at a level of performance approximately equivalent to the end of fourth grade. The middle school standards are set at a level of performance approximately equivalent to the end of eighth grade. The high school standards are set at a level of performance approximately equivalent to the end of tenth grade. It is expected that some students might achieve these levels earlier and others later than these grades.

The Science standards are founded upon both the American Association for the Advancement of Science's Project 2061 *Benchmarks for Scientific Literacy* and the National Research Council's *National Science Education Standards draft*. The Science standards will also take into account the work of the National Science Teachers Association as they revise their *Scope, Sequence, and Coordination Content Core* and develop assessment tasks.

These documents, each of which runs to several hundred pages, contain detail that amplifies the meaning of the terms used here.

ELEMENTARY SCHOOL

The student understands:

- the observable properties of objects and materials;
- motions of objects, in particular, push and pull, sound;
- heat, light, electricity, and magnetism.

MIDDLE SCHOOL

The student understands:

- characteristic properties of matter, in particular, density; conservation of matter;
- motions and forces, and the relationships among them, for example, effects of unbalanced forces;
- transfer and transformations of energy, including forms and conversion.

HIGH SCHOOL

The student understands:

- structure and properties of matter, in particular, composition of atoms, bonding, elements and compounds;
- chemical reactions, including concentration, pressure, temperature, catalysts;
- forces and motions, including net force, gravitational, electrical, magnetic;
- conservation of energy, in particular, transfer, heat;
- interactions of energy and matter, especially waves and wavelengths.

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2. Life Sciences Concepts

ELEMENTARY SCHOOL

The student understands:

- characteristics of organisms; that is, needs, environments that meet them; structures, especially senses; variation and behaviors, inherited and learned;
- life cycles, including birth, development, reproduction;
- organisms and environments, in particular, food chains, populations, effects on the environment;
- change over time, including fossil evidence.

MIDDLE SCHOOL

The student understands:

- structure and function of cells, tissues, and organs;
- reproduction and heredity, including genes, traits, and learning;
- regulation and behavior, especially the roles of senses and hormones;
- population and ecosystems, including food webs, resources, and energy;
- evolution, in particular, species, diversity and adaptation, variation, extinction.

HIGH SCHOOL

The student understands:

- cells, including structure and function, uses of energy and food;
- molecular basis of heredity, including DNA, chromosomes, mutations;
- behavior of organisms, especially hormones, nervous system, evolution;
- interdependence of organisms, especially flow of energy, cooperation and competition, environmental constraints;
- biological evolution, in particular, natural selection; and adaptation, including species, variation, extinction.

APPENDIX 3

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3. Earth and Space Sciences Concepts

APPENDIX 3

ELEMENTARY SCHOOL

The student understands:

- properties and uses of Earth materials, including rocks, soils, water, and gases;
- patterns, cycles, seasons, time, weather, and Earth motion;
- change over time, for example, erosion.

MIDDLE SCHOOL

The student understands:

- Earth's systems, including crustal plates and land forms; rock cycle, water cycle; weather and oceans;
- Earth's history, especially change over time, erosion, movement of plates, fossil evidence;
- Earth in the Solar System, including day, year; sun, planet; gravity, energy;
- natural resource management.

HIGH SCHOOL

The student understands:

- Earth's systems, including the Sun, radioactive decay, gravitational energy; weather and climate;
- origin and evolution of the Earth system, in particular, estimating geologic time, age of life forms;
- forces that shape the Earth; that is, processes and observable results;
- natural resource management.

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4. Scientific Connections and Applications

ELEMENTARY SCHOOL

The student understands:

- big ideas and unifying concepts, for example, order, models, form, change, cause and effect;
- the designed world, in particular, agriculture and technology;
- health, especially nutrition, germs, toxic substances, safety;
- science as a human endeavor.

MIDDLE SCHOOL

The student understands:

- big ideas and unifying concepts; for example, order and organization, models, systems, evolution and equilibrium, form and function, cause and effect, constancy and change;
- technology, including tradeoffs, constraints, feedback, risk;
- the designed world, including agriculture and industry;
- health, especially nutrition, exercise, and disease; toxic substances; safety; relationships with the environment;
- historical and contemporary impact of science.

HIGH SCHOOL

The student understands:

- big ideas and unifying concepts; for example, order and organization, models, systems, evolution and equilibrium, form and function, cause and effect, constancy and change;
- technology, including cost/benefit, constraints, feedback, risk;
- the designed world, including agriculture and industry;
- health, especially nutrition, exercise, and disease; toxic substances; safety; relationship to environment;
- historical and contemporary impact of science.

APPENDIX 3

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APPENDIX 3

ELEMENTARY SCHOOL

The student uses scientific reasoning strategies, scientific knowledge, and common sense to formulate questions about, understand, and explain a wide range of phenomena; that is, the student:

- asks questions about objects, organisms, and events in the world;
- seeks information from reliable sources, including scientific knowledge, observation, and trying things out;
- uses evidence to construct an explanation; recognizes a fair test;
- recognizes others' points of view; checks his or her own and others' explanations against experiences, observations, and knowledge;
- identifies problems, proposes and implements solutions, evaluates products or designs;
- works individually and in teams to collect and share information and ideas.

MIDDLE SCHOOL

The student uses scientific reasoning strategies, scientific knowledge, and common sense to formulate questions about, understand, and explain a wide range of phenomena; that is, the student:

- frames questions so that causes and effects can be distinguished; identifies variables that influence a situation and can be controlled;
- uses concepts from Standards 1 to 4 to explain a variety of observations and phenomena;
- uses evidence to develop descriptions, explanations, and models;
- proposes, recognizes, analyzes, considers, and critiques alternative explanations; distinguishes between fact and opinion;
- identifies problems; proposes and implements solutions; evaluates products or designs;
- works individually and in teams to collect and share information and ideas.

HIGH SCHOOL

The student uses scientific reasoning strategies, scientific knowledge, and common sense to formulate questions about, understand, and explain a wide range of phenomena; that is, the student:

- frames questions so that causes and effects can be distinguished; identifies variables that influence a situation and can be controlled;
- formulates and revises explanations and models based on evidence and logical argument, preserving significant information;
- proposes, recognizes, analyzes, considers, and critiques alternative explanations; distinguishes between fact and opinion;
- identifies problems or design opportunities; proposes designs and chooses among alternatives; implements a solution and evaluates its consequences;
- works individually and in teams to collect and share information and ideas.

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6. Scientific Tools and Technologies

ELEMENTARY SCHOOL

The student uses tools and technologies to collect and analyze data; that is, the student:

- uses simple technology and tools to gather data and extend the senses, for example, rulers, balances, thermometers, watches, magnifiers, and microscopes;
- collects and analyzes data, using concepts and skills in Mathematics Standard 4, Statistics and Probability Concepts;
- acquires information from print and non-print sources.

MIDDLE SCHOOL

The student uses tools and technologies to collect and analyze data; that is, the student:

- uses a variety of traditional and electronic tools to directly, indirectly, and remotely observe and measure objects, organisms, and phenomena;
- records and stores data in a variety of formats, including databases, audiotapes, and videotapes;
- analyzes data, while alert to observer and sample biases, using concepts and skills from Mathematics Standard 4, Statistics and Probability Concepts;
- acquires information from print, electronic, and visual sources, including computer databases.

HIGH SCHOOL

The student uses tools and technologies to collect and analyze data; that is, the student:

- uses a variety of traditional and electronic tools to directly, indirectly, and remotely observe and measure objects, organisms, and phenomena, being alert to accuracy and precision;
- records and stores data in a variety of formats, including databases, audiotapes, and videotapes;
- analyzes data, taking steps to limit observer and sample biases, using concepts and skills from Mathematics Standard 4, Statistics and Probability Concepts;
- acquires information from print, electronic, and visual sources, including the Internet.

APPENDIX 3

The General Accounting Office recently reported that more than half of 10,000 schools surveyed lacked modems and phone lines, that only 35% of schools and 3% of classrooms currently have access to the Internet. We know this is an equity issue—that far more than 3% of the homes in the United States have access to the Internet and that schools must make sure that students' access to information and ideas does not depend on what they get at home. Standard 6, Scientific Tools and Technologies, includes using telecommunications to acquire and share information. New Standards' partners have pledged to create the learning environments where students can develop the knowledge and skills delineated here.

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APPENDIX 3

ELEMENTARY SCHOOL

The student communicates clearly and effectively about the natural world; that is,the student:

- represents data and results in more than one way, for example, numbers, drawings, words, tables;
- uses facts to support conclusions;
- critiques written and oral explanations;
- writes instructions that others can follow;
- communicates in a form suited to the purpose and the audience; uses data to resolve disagreements.

MIDDLE SCHOOL

The student communicates clearly and effectively about the natural world; that is, the student:

- represents data and results in multiple ways; for example, numbers and statistics; drawings, diagrams, and pictures; sentences; charts and tables; models;
- argues from evidence, including his or her own data and the data of others;
- critiques published materials;
- explains a scientific concept or procedure to other students;
- communicates in a form suited to the purpose and the audience; responds to critical comments with data.

HIGH SCHOOL

The student communicates clearly and effectively about the natural world; that is, the student:

- represents data and results in multiple ways; for example, numbers and statistics; drawings, diagrams, and pictures; sentences; charts and tables; models; and uses the most effective way to make the point;
- summarizes varied sources of evidence, including his or her own data and published reports;
- critiques published materials, including popular and academic sources;
- explains a scientific concept or procedure to other students;
- communicates in a form suited to the purpose and the audience; responds to critical comments with data and reasoning.

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8. Scientific Investigation

ELEMENTARY SCHOOL

The student completes projects drawn from the following kinds of investigation, including at least one full investigation each year and, over the course of elementary school, investigations representing all four kinds.

- Experiment; that is, conducting a fair test;
- Systematic observation;
- Design;
- Research using print and electronic (that is, video or computer) information.

A single project may draw on more than one type of investigation.

A full investigation includes:

- questions that can be studied using the resources available;
- procedures that are safe, humane, and ethical; respect privacy and property rights;
- data that have been collected and recorded (see also Science Standard 6) in ways that others can verify, and analyzed using skills expected at this grade level (see also Mathematics Standard 4);
- data and results that have been represented (see also Science Standard 7) in ways that fit the context;
- recommendations, decisions, and conclusions based on evidence;
- acknowledgment of references and contributions of others;
- results that are communicated appropriately to audiences;
- reflection and defense of conclusions and recommendations from other sources and peer review.

MIDDLE SCHOOL

The student completes projects drawn from the following kinds of investigation, including at least one full investigation each year and, over the course of middle school, investigations representing all four kinds.

- Controlled experiment;
- Fieldwork;
- Design;
- Secondary research; that is, use of others' data.

A single project may draw on more than one type of investigation.

A full investigation includes:

- questions that can be studied using the resources available;
- procedures that are safe, humane, and ethical; respect privacy and property rights;
- data that have been collected and recorded (see also Science Standard 6) in ways that others can verify, and analyzed using skills expected at this grade level (see also Mathematics Standard 4);
- data and results that have been represented (see also Science Standard 7) in ways that fit the context;
- recommendations, decisions, and conclusions based on evidence;
- acknowledgment of references and contributions of others;
- results that are communicated appropriately to audiences;
- reflection and defense of conclusions and recommendations from other sources and peer review.

HIGH SCHOOL

The student completes projects drawn from the following kinds of investigation, including at least one full investigation each year and, over the course of high school, investigations representing all four kinds.

- Controlled experiment;
- Fieldwork;
- Design;
- Secondary research; that is, use of others' data.

A single project may draw on more than one type of investigation.

A full investigation includes:

- questions that can be studied using the resources available;
- procedures that are safe, humane, and ethical; respect privacy and property rights;
- data that have been collected and recorded (see also Science Standard 6) in ways that others can verify, and analyzed using skills expected at this grade level (see also Mathematics Standard 4);
- data and results that have been represented (see also Science Standard 7) in ways that fit the context;
- recommendations, decisions, and conclusions based on evidence;
- acknowledgment of references and contributions of others;
- results that are communicated appropriately to audiences;
- reflection and defense of conclusions and recommendations from other sources and peer review.

APPENDIX 3

Best practice in Science has always included extensive inquiry and investigation, but it is frequently given less emphasis at the elementary and middle school levels. There are many opportunities to learn Science outside of school, including Scouts, Boys and Girls Clubs, 4-H and Future Farmers of America. The work done in these venues can and should be used to provide evidence of meeting the standards.

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APPENDIX 4

The elementary school standards are set at a level of performance approximately equivalent to the end of fourth grade. The middle school standards are set at a level of performance approximately equivalent to the end of eighth grade. The high school standards are set at a level of performance approximately equivalent to the end of tenth grade. It is expected that some students might achieve these levels earlier and others later than these grades.

The standards for Applied Learning have been revised substantially since the last published draft of these Performance Standards. Contact New Standards for information about the content framework that has provided the foundation for the Applied Learning standards.

ELEMENTARY SCHOOL

The student completes projects involving at least two of the following kinds of problem solving each year and, over the course of elementary school, projects involving all three kinds of problem solving.

- Designing: identifying needs that could be met by new products, services, or systems; and creating solutions for meeting them;
- Planning and Organizing: taking responsibility for all aspects of planning and organizing an event or activity from concept to completion, making good use of the resources of people, time, money, and materials and facilities;
- Improving a System: developing an understanding of the way systems of people, machines, and processes work; troubleshooting problems in their operation; and devising strategies for improving their effectiveness.

A single project may involve more than one kind of problem solving.

Designing

The student designs a product, service, or system to meet an identified need; that is, the student:

- develops ideas for design of the product, service, or system;
- identifies factors affecting choice of the best idea for the design and makes a decision based on those factors;
- selects and uses an appropriate form for presenting the design plan;
- establishes criteria for judging the success of the design;
- plans and carries out the steps of the production process;
- evaluates the quality of the design by considering the criteria for success and by comparison with similar products, services, or systems.

Planning and Organizing

The student plans and organizes an event or activity; that is, the student:

- develops a plan that:
  - includes all the factors and variables that need to be considered;
  - makes sense in terms of the order in which things need to be done;
  - makes sense in terms of the people, time, and resources available to put the plan into action;
  - is described clearly enough for someone else to use it;
- implements the plan;
- evaluates the success of the event or activity, identifying the parts of the plan that worked best and the aspects that could have been improved by better planning and organization, and proposing how the improvements could have been achieved;
- makes recommendations to others who might consider planning and organizing a similar event or activity.

Improving a System

The student troubleshoots problems in the operation of a system in need of repair or devises and tests ways of improving the effectiveness of a system in operation; that is, the student:

- identifies the parts of the system and the way the parts connect with each other;
- identifies parts or connections in the system that have broken down or that could be made to work better;
- devises ways of making the system work again or making it work better;
- checks whether the strategies worked.

MIDDLE SCHOOL

The student completes projects involving at least two of the following kinds of problem solving each year and, over the course of middle school, projects involving all three kinds of problem solving.

- Designing: identifying needs that could be met by new products, services, or systems; and creating solutions for meeting them;
- Planning and Organizing: taking responsibility for all aspects of planning and organizing an event or activity from concept to completion, making good use of the resources of people, time, money, and materials and facilities;
- Improving a System: developing an understanding of the way systems of people, machines, and processes work; troubleshooting problems in their operation; and devising strategies for improving their effectiveness.

A single project may involve more than one kind of problem solving.

Designing

The student designs a product, service, or system to meet an identified need; that is, the student:

- develops a range of design options;
- selects one design option to pursue and justifies the choice, for example, with reference to functional, aesthetic, social, economic, or environmental considerations;
- identifies, where relevant, the principles on which the decision was based, such as aesthetic, mathematical, scientific;
- uses appropriate conventions to represent the design;
- establishes criteria for judging the success of the design;
- plans and carries out the steps of the production process;
- adjusts the production process as required to achieve specified standards of quality and safety;
- evaluates the quality of the design by considering the criteria for success and by comparison with similar products, services, or systems.

Planning and Organizing

The student plans and organizes an event or activity; that is, the student:

- develops a plan that:
  - reflects research into relevant precedents and regulations;
  - includes all the factors and variables that need to be considered;
  - makes sense in terms of the order in which things need to be done;
  - makes sense in terms of the people, time, and resources available to put the plan into action;
  - is described clearly enough for someone else to use it;
- implements the plan in ways that:
  - reflect established priorities;
  - respond effectively to unforeseen circumstances;
- evaluates the success of the event or activity, identifying the parts of the plan that worked best and the aspects that could have been improved by better planning and organization, and proposing how the improvements could have been achieved;
- makes recommendations to others who might consider planning and organizing a similar event or activity.

Improving a System

The student troubleshoots problems in the operation of a system in need of repair or devises and tests ways of improving the effectiveness of a system in operation; that is, the student:

- describes the management and structure of the system in terms of its logic, sequences, and control;
- identifies the operating principles underlying the system, i.e., mathematical, scientific, organizational;
- analyzes the design and management of the system with reference to its functional, aesthetic, social, commercial, and environmental requirements, as appropriate;
- evaluates the operation of the system;
- devises strategies for putting the system back in operation or improving its performance;
- tests the effectiveness of the strategies employed.

HIGH SCHOOL

The student completes projects involving at least two of the following kinds of problem solving each year and, over the course of high school, projects involving all three kinds of problem solving.

- Designing: identifying needs that could be met by new products, services, or systems, and creating solutions for meeting them;
- Planning and Organizing: taking responsibility for all aspects of planning and organizing an event or activity from concept to completion, making good use of the resources of people, time, money, and materials and facilities;
- Improving a System: developing an understanding of the way systems of people, machines, and processes work; troubleshooting problems in their operation; and devising strategies for improving their effectiveness.

A single project may involve more than one kind of problem solving.

Designing

The student designs a product, service, or system to meet an identified need; that is, the student:

- develops a design proposal that:
  - shows how the ideas have been developed;
  - reflects awareness of similar work done by others and of relevant design standards and regulations;
  - justifies the choices made, for example, with reference to functional, aesthetic, social, economic, and environmental considerations;
  - describes, where relevant, the principles on which decisions were based, such as, aesthetic, mathematical, and scientific;
  - establishes criteria for evaluating the product, service, or system;
  - uses appropriate conventions to represent designs;
  - communicates clearly so that a peer or colleague could use it;
- organizes, implements, and adjusts the production process to:
  - achieve specified standards of quality and safety;
  - make efficient use of time and resources;
- evaluates the product, service, or system in terms of the criteria established in the design proposal, using:
  - information gathered from impact studies or product testing or market research, as appropriate;
  - comparisons with similar work done by others.

Planning and Organizing

The student plans and organizes an event or activity; that is, the student:

- develops a planning schedule that:
  - is sensible in terms of the goals of the event or activity;
  - is logical and achievable;
  - reflects research into relevant precedents and regulations;
  - takes account of all relevant factors;
  - reflects strategic thinking;
  - communicates clearly so that a peer or colleague could use it;
- implements and adjusts the planning schedule in ways that:
  - achieve specified standards of quality;
  - make efficient use of time, money, people, resources, facilities;
  - reflect established priorities;
  - respond effectively to unforeseen circumstances;
- evaluates the event or activity using qualitative and quantitative methods to determine:
  - the success of the event or activity in terms of its established purposes;
  - aspects of the event or activity that could have been improved by better planning and organization and the ways by which the improvements could have been achieved;
  - recommendations for planning and organizing subsequent similar events or activities.

Improving a System

The student troubleshoots problems in the operation of a system in need of repair or devises and tests ways of improving the effectiveness of a system in operation; that is, the student:

- explains the management and structure of the system in terms of its:
  - logic, sequences, and control;
  - impact;
  - operating principles, that is, the mathematical, scientific and/or organizational principles underlying the system;
- analyzes the design and management of the system, taking account of its functional, aesthetic, social, environmental, and commercial requirements, as appropriate, and using a relevant kind of modeling and systems analysis;
- evaluates the operation of the system using qualitative methods and/or quantitative measurements of performance;
- adapts techniques to control and manage the system in order to improve its performance by:
  - identifying, testing, and adjusting sub-systems;
  - developing and testing strategies to optimize performance.

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APPENDIX 4

ELEMENTARY SCHOOL

The student makes an oral presentation of project plans or findings to an appropriate audience; that is, the student:

- organizes the presentation in a logical way appropriate to its purpose;
- speaks clearly and presents confidently;
- responds to questions from the audience;
- evaluates the effectiveness of the presentation.

The student composes and sends correspondence, such as thank-you letters and memos providing information; that is, the student:

- expresses the information or request clearly;
- writes in a style appropriate to the purpose of the correspondence.

The student writes and formats information for short publications, such as brochures or posters; that is, the student:

- collects information to include in the publication;
- organizes the information into an appropriate form for use in the publication;
- checks the information for accuracy;
- formats the publication so that it achieves its purpose.

The student translates information from one format to another; that is, the student:

- chooses a different format that is appropriate for presenting information to better suit the purpose for communicating it;
- checks that the information has been translated accurately into the new format;
- gives reasons for any changes made in the information, such as deciding to leave some information out.

MIDDLE SCHOOL

The student makes an oral presentation of project plans or findings to an audience beyond the school; that is, the student:

- organizes the presentation in a logical way appropriate to its purpose;
- adjusts the style of presentation to suit its purpose and audience;
- speaks clearly and presents confidently;
- responds appropriately to questions from the audience;
- evaluates the effectiveness of the presentation.

The student conducts formal written correspondence with a community organization or business; that is, the student:

- expresses the information or request clearly for the purpose and audience;
- writes in a style appropriate to the purpose and audience of the correspondence.

The student organizes and communicates information for publication using several methods and formats, such as overhead transparencies, handouts, and computer generated graphs and charts; that is, the student:

- collects information to include in published materials;
- organizes the information into an appropriate form for use in the publication, taking account of the requirements and possibilities of the chosen format;
- checks the information for accuracy;
- formats the published material so that it achieves its purpose.

The student translates information from one format to another; that is, the student:

- chooses a different format that is appropriate for presenting information to better suit the purpose for communicating it;
- checks that the information has been translated accurately into the new format;
- gives reasons for any changes made in the information, such as deciding to leave some information out.

HIGH SCHOOL

The student makes an oral presentation of project plans or findings to an audience with expertise in the relevant subject matter; that is, the student:

- organizes the presentation in a logical way appropriate to its purpose;
- adjusts the style of presentation to suit its purpose and audience;
- speaks clearly and presents confidently;
- responds appropriately to questions from the audience;
- evaluates the effectiveness of the presentation.

The student prepares a formal written proposal or report to a community organization or business; that is, the student:

- organizes the information in the proposal or report in a logical way appropriate to its purpose;
- produces the proposal or report in a format similar to that used in professionally produced documents for a similar purpose and audience.

The student develops a multi-media presentation, combining text, sound, and images; that is, the student:

- selects an appropriate medium for each element of the presentation;
- uses the selected media skillfully, including editing and monitoring for quality;
- makes smooth transitions between the elements of the presentation;
- achieves coherence in the presentation as a whole;
- communicates the information effectively, testing audience response and revising the presentation accordingly.

The student translates information from one format to another; that is, the student:

- chooses a different format appropriate for presenting information to better suit the purpose for communicating it;
- checks that the information has been translated accurately into the new format;
- justifies any changes made in the information, including the omission of material irrelevant to the purpose of the communication.

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3. Information Technology Tools and Techniques

APPENDIX 4

ELEMENTARY SCHOOL

The student:

- uses word processing, graphics, and drawing programs;
- uses an electronic card catalogue.

MIDDLE SCHOOL

The student:

- loads, runs, and uses database and spreadsheet programs;
- acquires information for specific purposes from on-line sources;
- uses documentation and on-screen help to learn how to use software programs.

HIGH SCHOOL

The student:

- sets up and operates computer equipment and associated peripherals;
- troubleshoots problems in operating computer equipment and software;
- uses on-line sources to exchange information for specific purposes.

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APPENDIX 4

ELEMENTARY SCHOOL

The student learns from role models; that is, the student:

- consults with or observes older students and adults at work and identifies the main features of what they do, the way they go about their work, and the qualities of the products they produce;
- takes account of role models in planning and conducting his or her own project activities.

The student keeps records of work activities in an orderly manner; that is, the student:

- sets up a system for storing records of work activities;
- maintains records of work activities in a way that makes it possible to find specific materials quickly and easily.

The student identifies strengths and weaknesses in his or her own work; that is the student:

- understands and establishes criteria for judging the quality of work processes and products;
- assesses his or her own work processes and products.

MIDDLE SCHOOL

The student learns from role models; that is, the student:

- consults with or observes older students and adults at work and identifies the main features of what they do, the way they go about their work, and the qualities of the products they produce;
- analyzes work performances and work products to identify factors affecting success;
- takes account of analyses of role models in planning and conducting his or her own project activities.

The student develops and maintains a schedule of work activities; that is, the student:

- establishes a schedule of work activities that reflects priorities and deadlines;
- seeks advice on the management of conflicting priorities and deadlines;
- updates the schedule regularly.

The student sets goals for learning and reviews his or her progress; that is, the student:

- sets goals for learning;
- reviews his or her progress towards meeting the goals;
- seeks and responds to advice from others in setting goals and reviewing progress.

HIGH SCHOOL

The student learns from adult role models; that is, the student:

- consults with and observes adult role models at work and identifies the elements of their work roles and the qualities of the their work products;
- analyzes the work performance of adult role models to determine the critical demands of the role, such as demands for knowledge and skills, judgment and decision making;
- takes account of analyses of role models in planning and conducting his or her own project activities.

The student reviews his or her own progress in completing work activities and adjusts priorities as needed to meet deadlines; that is, the student:

- develops and maintains work schedules that reflect consideration of priorities;
- manages time;
- monitors progress towards meeting deadlines and adjusts priorities as necessary.

The student evaluates his or her performance; that is, the student:

- establishes expectations for his or her own achievement;
- critiques his or her work in light of the established expectations;
- seeks and responds to advice and criticism from others.

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APPENDIX 4

ELEMENTARY SCHOOL

The student works with others to complete a task; that is, the student:

- reaches agreement with group members on what work needs to be done to complete the task and how the work will be tackled;
- takes a share of the responsibility for the work;
- consults with group members regularly during the task to check on progress in completing the task, to decide on any changes that are required, and to check that all parts have been completed at the end of the task.

The student shows or explains something clearly enough for someone else to be able to do it.

The student identifies the needs of a client; that is, the student:

- interprets a written request for completion of a task;
- asks questions to clarify the demands of a task.

MIDDLE SCHOOL

The student takes responsibility for a component of a team project; that is, the student:

- reaches agreement with team members on what work needs to be done to complete the task and how the work will be tackled;
- takes specific responsibility for a component of the project;
- takes all steps necessary to ensure appropriate completion of the specific component of the project within the agreed upon time frame.

The student coaches or tutors; that is, the student:

- assists one or more others to learn on the job, e.g., in school, sports, and community groups;
- analyzes coaching or tutoring experience to identify more and less effective ways of providing assistance to support on-the-job learning;
- uses the analysis to inform subsequent coaching or tutoring activities.

The student negotiates with a client; that is, the student:

- consults with a client to clarify the demands of a task;
- interprets the client's request and translates it into an initial plan for completing the task, taking account of available resources;
- negotiates with the client to arrive at an agreed upon plan.

HIGH SCHOOL

The student participates in the establishment and operation of self-directed work teams; that is, the student:

- identifies the range of knowledge and skills required for a given project;
- defines roles and shares responsibilities among team members;
- sets objectives and time frames for the work to be completed;
- establishes processes for group decision making;
- reviews progress and makes adjustments as required.

The student plans and carries out a strategy for introducing others into a work program; that is, the student:

- establishes learning goals;
- plans a sequence of activities designed to achieve the learning goals;
- monitors the learning process and revises activities accordingly;
- evaluates the success of the strategy and identifies aspects of the process that could have been improved and the ways by which the improvements could have been achieved.

The student completes a task in response to a commission from a client; that is, the student:

- negotiates with the client to arrive at a plan for meeting the client's needs that is acceptable to the client, achievable within available resources, and includes agreed-upon criteria for successful completion;
- monitors client satisfaction with the work in progress and makes adjustments accordingly;
- evaluates the result in terms of the negotiated plan and the client's evaluation of the result.

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STANDARDS DEVELOPMENT STAFF

Ann Borthwick, Learning Research and Development Center, University of Pittsburgh

Bill Calder, Fort Worth Independent School District, TX

Shannon C'de Baca, Thomas Jefferson High School, Council Bluffs, IA

Janet Coffey, Edmund Burke School, Washington, DC

Duane A. Cooper, Center for Mathematics Education and Department of Mathematics, University of Maryland

Phil Daro, Academic Advancement, University of California Office of the President

Diana Edwards, Learning Research and Development Center, University of Pittsburgh

Gary Eggan, Learning Research and Development Center, University of Pittsburgh

Sally Hampton, Fort Worth Independent School District, TX

Drew Kravin, Cornell Elementary School, Albany, CA

Georgia Makris, Academic Advancement, University of California Office of the President

Mary Marsh, Fort Worth Independent School District, TX

Kate Nolan, Learning Research and Development Center, University of Pittsburgh

Andy Plattner, National Center on Education and the Economy

Lonny Platzer, Learning Research and Development Center, University of Pittsburgh

Jennifer Quinn, Fort Worth Independent School District, TX

Mark Rasmussen, Cornell Elementary School, Albany, CA

Ann Shannon, Graduate School of Education, University of California at Berkeley

Liz Spalding, National Council of Teachers of English

Elizabeth Stage, Academic Advancement, University of California Office of the President

Dick Stanley, Dana Center, University of California at Berkeley

Cathy Sterling, Academic Advancement, University of California Office of the President

John Tanner, Fort Worth Independent School District, TX

Ginny Van Horne, Education and Human Resources, American Association for the Advancement of Science

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Peter Afflerbach, University of Maryland

Bob Anderson, Department of Education, CA

Laura Arndt, Eaglecrest High School, Aurora, CO

Rob Atterbury, San Diego City Schools, CA

Jerry Bell, Education and Human Resources, American Association for the Advancement of Science

Neal Berkin, White Plains Schools, White Plains, NY

Victoria Bill, Institute for Learning, Learning Research and Development Center, University of Pittsburgh

Ruben Carriedo, San Diego City Schools, CA

Linda Carstens, San Diego City Schools, CA

Miriam Chaplin, National Council of Teachers of English

Lynda Chittenden, Park Elementary, Mill Valley, CA

Fran Claggett

Marsha DeLain, Delaware Department of Public Instruction

Xandra Williams Earlie, Aldine Independent School District, Houston, TX

Joanne Eresh, Pittsburgh Public Schools, PA

Ed Esty, Independent Consultant, Chevy Chase, MD

Alan Farstrup, International Reading Association

Karen Fujii, Bucher Middle School, Santa Clara, CA

Matt Gandal, American Federation of Teachers

Karrie Gengo, Meadowdale High School, Lynnwood, WA

Stacy Goodman, Lewis Central Schools, Council Bluffs, IA

Eunice Greer, University of Illinois

Mike Hale, Council Bluffs Community Schools, Council Bluffs, IA

Shirley Brice Heath, Stanford University

Bill Honig, San Francisco State University

Beth Hulbert, Ward 5, Barre, VT

Tom Jones, National Alliance for Restructuring Education

Nancy Kellogg, CONNECT, Colorado Department of Education

Don King, Department of Mathematics, Northeastern University

Linda Lewis, Fort Worth Independent School District, TX

Bob Livingston, Pennsylvania Department of Education

Gary MacDonald, Junior High School, Greely, CO

Shirley Malcom, American Association for the Advancement of Science

Megan Martin, California Department of Education

Rich Matthews, Pittsburgh Public Schools, PA

Jim Meadows, Mountlake Terrace High School, Mountlake Terrace, WA

Monty Multanen, Edmonds School District, WA

Miles Myers, National Council of Teachers of English

Lee Odell, Rensselaer Polytechnic Institute, Troy, NY

Gary Oden, Institute for Learning, Learning Research and Development Center, University of Pittsburgh

Kevin Padian, Department of Integrative Biology, University of California at Berkeley

David Pearson, Michigan State University

Charles Peters, Oakland Michigan Schools

Marge Petit, Vermont Institute for Mathematics, Science, and Technology

Cindy Phillips, Tri City Elementary, Myrtle Creek, Oregon

John Porter, National Alliance for Restructuring Education

Robert Probst, University of Georgia

Fred Quinonez, Overland Trail Middle School, Brighton, CO

Susan Radley, Teachers College Writing Project at Columbia University, NY

Ginny Redish, Redish & Associates, Inc.

Eeva Reeder, Mountlake Terrace High School, Mountlake Terrace, WA

Don Rubin, University of Georgia

Robert Rueda, University of Southern California

Marge Sable, National Alliance for Restructuring Education

Sandy Short, Hillview Crest Elementary School, New Haven Unified School District, CA

Sandy Smith, Harrison High School, Aurora, CO

Dave Steward, John Evans Jr. High School, Greely, CO

John Swang, National Science Research Center, Mandeville, LA

Carol Tateishi, Bay Area Writing Project

Johnny Tolliver, Delaware State University

Ann Tweed, Eaglecrest High School, Aurora, CO

John Vibber, Mt. Abraham Union High School, Briston, VT
Darby Williams, Sacramento County Office of Education, CA
Dale Vigil, San Diego City Schools, CA
Dennie Wolf, Harvard PACE
Victoria Young, Texas Education Agency

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700 Eleventh Street, NW • Suite 750 • Washington DC 20001
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